Principles of American Forestry

Samuel B. Green

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WORKS OF

PROFESSOR SAMUEL B. GREEN

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PRINCIPLES

OF

AMERICAN FORESTRY.

BY

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Late Professor of Horticulture and Forestry, University of Minnesota; Member of the Forest Reserve Board of the State of Minnesota; Author of "Forestry in Minnesota."

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PREFACE.

This is a book on elementary forestry, and has been prepared especially for students and others beginning this subject. It is also intended for the general reader who wishes to secure a general idea of the subject of forestry in North America.

Much of the matter included herein was originally published by the Geological and National History Survey of Minnesota under the title "Forestry in Minnesota." The favor with which that work was received has encouraged the publishers to get out this volume, in which the matter is treated in a more general way and enlarged to better adapt it to the whole country.

Samuel B. Green.

University of Minnesota,
St. Anthony Park, Minn., April, 1903.

ACKNOWLEDGMENTS.

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Figure 49 is loaned by Professor John Gifford.

" 14 is loaned by Mr. H. B. Ayres.

" 50 is from W. H. Rau.

CONTENTS.

CHAPTER I.

THE TREE.

TREE GROWTH.

CHAPTER II.

THE FOREST.

CHAPTER III.

FOREST INFLUENCES.

CHAPTER IV.

TREE PLANTING ON PRAIRIES.

CHAPTER V.

FOREST REGENERATION.

CHAPTER VI.

PROPAGATION.

CHAPTER VII.

NURSERY PRACTICE.

CHAPTER VIII.

FOREST PROTECTION.

CHAPTER IX.

RATE OF INCREASE IN TIMBER TREES.

CHAPTER X.

FOREST MENSURATION.

CHAPTER XI.

FOREST PROBLEMS.

CHAPTER XII.

THE USES OF WOOD.

CHAPTER XIII.

DURABILITY OF WOOD.

CHAPTER XIV.

FOREST ECONOMICS.

CHAPTER XV.

LIST OF ILLUSTRATIONS.

M-P.40c

PRINCIPLES OF AMERICAN FORESTRY.

25992

CHAPTER I.

THE TREE.

A TREE is a woody plant with a single stem more or less branched and taking on what is commonly known as the tree form.

The most evident parts of a tree are roots, stem or trunk, branches, buds, leaves, flowers, fruit, and seed.

The Stem, Branches, and Roots are made up of inner bark, outer bark, sapwood, and heartwood. The outer bark, sapwood, and heartwood are made up of concentric circles termed annual rings. During each period of growth two new rings are formed—one on the outside of the sapwood and another on the inside of the outer bark, and as we seldom have more than one season of growth each year but one ring is formed on the wood in a year; so that by counting the rings of wood in the stem we can determine very closely the age of trees. In very rare cases we have two periods of growth and two rings of wood in one year, as in 1894, when the drought of midsummer ripened up the wood of the trees by the first of August and the rains of autumn started a new growth and caused some trees and shrubs to flower in October, but such occurrences are very uncommon and the extra rings formed are readily detected by their being smaller than adjoining rings and less distinctly defined. The age of trees could be told by the rings of the outer bark nearly as well as by those of the

wood were it not for the fact that the outer layers of bark fall off as the tree grows older.

Wood once hardened never changes, and the branches are practically always at the same height from the ground They might be raised a little by the thickening of the main roots.

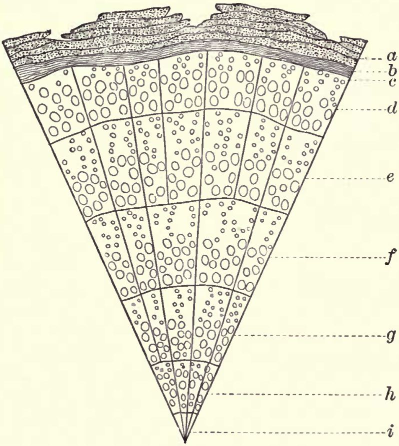

FIG. 1.—Cross-section of Woody Stem. Diagram showing (*a*) outer bark, (*b*) inner bark or bast, (*c*) cambium, (*d*, *e*, *f*, *g*, and *h*) annual rings of wood, and (*i*) pith.

In some experiments the bark of rapidly growing branches was peeled back in the spring for a few inches, the wood covered with tin-foil and the bark replaced. At the end of the season there was found a ring of wood outside of the tin-foil, thus showing where the annual growth of the tree was made.

The Bark covers the whole exterior surface of the trunk, branches, and roots and serves as a protection. It is made

up of two parts, the outer or corky layer which is dead bark and the inner or live bark. These vary much in appearance and thickness on different kinds of trees. For instance, on the White Birch the corky layer is pure white, very thin and tough, while on our White Pine it is very dark brown and often an inch or more in thickness and quite brittle.

The Sapwood is the portion of thewood next to the bark. It varies much in thickness in different species and in trees of the same species; the most rapidly grown trees contain the largest amount. It is the most active portion of the wood in the growing tree, and contains considerable plant-food and more water than the heartwood.

The Heartwood is the wood in the centre of the trunk and is generally distinguished from the sapwood by its more compact structure and darker color, though in some cases it may be lighter colored than the sapwood. It is also harder and more valuable for fuel, shrinks less in drying, and is more durable in contact with the soil than the sapwood. There is very little movement of the sap in the heartwood.

The Roots furnish water and nourishment that the plant receives from the soil, but only the young roots have the power of taking up the soil water; the older roots are most useful in holding the tree in place. It is common to classify roots into surface roots and tap-roots, depending on their shape and the depth they go in the ground. Some trees have nearly all surface roots, as the Birch and Spruce, others have nearly all tap-roots, which often go to a great depth on dry land, as those of the Bur Oak, White Oak, Black Walnut, and Butternut. Most of our trees have a combination of the two kinds, as the Maple, Hackberry, and Ash. Seedling trees of most kinds have a decided tap-root when young, but in many species it ceases to grow downward when a few years old. This is true of the Red

and Scarlet Oaks, which often have a tap-root extending four feet in depth before the tree has attained a corresponding height above ground, but after about five years large lateral roots develop and the growth of the tap-root nearly ceases.

Root-growth is relatively less to the extent of ground

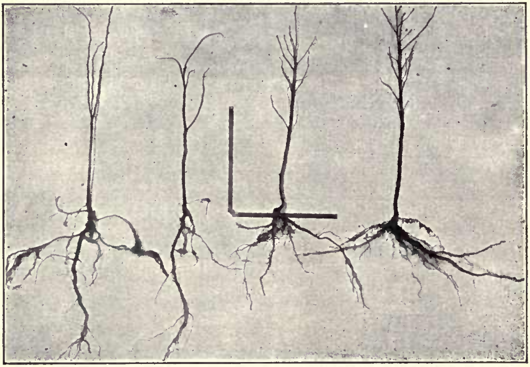

FIG. 2.—Characteristic Root Formation. On the left two Hackberry, on the right two White Birch, each two-year seedlings from same seed-bed; the first with a divided tap-root, the second without tap-root.

occupied in moist and fertile soil than in dry and poor soil. but the roots are proportionately more branched. In wet seasons the root development is less for a given plant than in dry seasons, because the roots may get their needed food and water from a small area. Nursery trees grown on moist rich land have a more compact root system than those grown on poor land.

At the Minnesota Experiment Station a small Bur Oak

growing on dry, gravelly soil had a tap-root that was evidently twenty feet long, while on moist fertile clay land in the same section such trees probably seldom have tap-roots more than six feet long.

Buds are placed regularly on the young branches and are said to be either alternate or opposite. When they occur on the stump or on roots they are not arranged in any regular order. There are two kinds of buds—flower-buds, which develop into flowers and fruit; and leaf-buds, which develop into leaves and branches. These can generally be distinguished from each other by their shape and size and by cutting through them and noting their construction. Flower-buds are generally more liable to injury from climatic changes than leaf-buds.

The Leaves of our trees vary much in size and shape. They are simple when composed of but one piece, as the leaves of the Oak, Maple, and Birch, and compound when composed of more than one piece, as the leaves of the Locust, Ash, and Black Walnut. Leaves are made up of a framework filled in with cellular tissue and covered with a thin skin. This skin has very many small pores in it called stomata, through which the plant takes in carbon dioxide from the air and gives off oxygen and water.

All our trees shed at least a part of their leaves each year. All the broad-leaved trees and the Tamarack shed their entire foliage yearly, while our so-called evergreen trees lose a part of their leaves each year. The length of time leaves remain on this latter class of trees varies from two or three years, in the case of White Pine growing in very severe locations, to perhaps eight years, in the case of Red Cedar favorably located. The time that leaves remain on the branches of evergreens depends to some extent on the location and age of the individual tree.

The following table gives the approximate length of time that leaves of conifers remain on trees in Minnesota:

LENGTH OF TIME THAT LEAVES OF CONIFERS REMAIN ON TREES IN MINNESOTA.

Botanical Name.	Common Name.	Year of Falling.
Pinus strobus	White Pine	2d and 3d.
Pinus flexilis	Western White Pine	5th and 6th.
Pinus resinosa	Norway Pine	4th and 5th.
Pinus divaricata	Jack Pine	2d and 3d.
Pinus ponderosa scopulorum	Bull Pine	3d and 4th.
Pinus sylvestris	Scotch Pine	3d.
Pinus laricio austriaca	Austrian Pine	4th and 5th.
Pinus montana pumila	Dwarf Pine	5th, 6th, and 7th.
Larix laricina	Tamarack	1st winter.
Larix europea	European Larch	1st winter.
Picea canadensis	White Spruce	4th and 5th.
Picea mariana	Black Spruce	4th and 5th.
Picea parryana	Blue Spruce	6th and 7th.
Picea engelmanni	Engelmann Spruce	5th and 6th.
Picea excelsa	Norway Spruce	5th.
Tsuga canadensis	Hemlock	2d and 3d.
Pseudotsuga taxifolia	Douglas Spruce	5th.
Abies balsamea	Balsam Fir	5th.
Abies concolor	White Fir	5th.
Thuja occidentalis	Arborvitæ	4th and 5th.
Juniperus virginiana	Red Cedar	5th and 6th.
Juniperus communis	Dwarf Juniper	5th and 6th.

Flowers are parts of the plant especially modified for the reproduction of the plant by seed. Both sexual organs may be located together in the same flower, as those of the Basswood, Mountain Ash, and Cherry; or in separate flowers on the same plant, as those of the Birch, Oak, and Black Walnut; or they may be separate on entirely different plants, as in the Willow, Poplar, Box-elder. and Ash.

The Fruit, botanically defined, is the seed-containing area, derived from a single flower. As used in nursery practice the term is generally applied to seeds having a fleshy covering or an adjoining fleshy part.

The Seed, botanically defined, is the ripened ovule, but as the term is used in nursery practice it often includes the ovary and other parts that may be attached to it. What

is commonly called the seed of Maple, Ash, Elm, Walnut, and Basswood is really the fruit.

Distribution of Seeds. The seeds of plants are distributed in various ways, the most common of which are (1) by means of floats or wings which buoy the seeds up in the air or water, and (2) by animals. The seeds of Ash, Arborvitæ, Box-elder, Catalpa, Elm, Maple, Pine, and Spruce have wings which allow them to be blown great distances by the wind, especially when they break loose from the upper branches of high trees during severe winds. The seeds of the Honey Locust are not shed from the pod until after it has fallen, and as the pod is ten inches or more long and spirally twisted it may be blown long distances on level ground or snow crust. The seeds of the poplars and willows have a cottony float attachment which buoys them up in the air. In the case of the Basswood, the parachute-like bract attached to the seed-cluster aids in spreading the seeds by carrying them through the air or along the snow crust. The seeds of Mountain Ash, Wild Black Cherry, Hawthorn, and others are largely distributed by wild animals which eat the fruit and allow the seeds to pass through the alimentary canal uninjured or carry off the fruit and spit out the seeds. Many seeds or seed-vessels have bur-like or sticky coats by which they adhere to animals and are thus carried considerable distances. Very often bodies of water aid in the distribution of seeds, since all that are spread by the agency of the wind and most of those that have fleshy coverings will float on the surface of the water and may in this way be scattered.

Shapes of Trees. Different species of trees naturally develop different shapes. Some, like Spruces, Tamarack, and Balsam, have a decided tendency to form a strong stem and to take on a conical form in preference to the development of a crown or head; while others, like the Basswood, Oaks, Maples, and Box-elder, develop their crown in pref-

erence to their stem. The actual shape of trees depends on the space they have to grow in, on the soil, situation, and on the age of the trees. Where trees have plenty of room to grow, and their natural development is not interfered with, their individual characteristics are most apparent.

TREE-GROWTH.

Assimilation. Plants are made up of various tissues and these are formed of numerous cells. The material of which the cells are composed is largely carbon. This carbon is derived from the carbon dioxide of the air which enters into the leaves and under the action of light, air, and water is there decomposed; the oxygen is given off and the carbon is retained, and, combined with water obtained from the roots, forms starch, sugar, gum, and other plant-foods.

This process of food-making is called assimilation and can be carried on only in the green parts of the plant, and in these only when exposed to light and air. Hence, foliage, air, and light at the top are essential prerequisites for tree-growth, and, other conditions being favorable, the greater quantity and better development of foliage and the more light this foliage has at its disposal for its work the more vigorously will the tree grow.

In general, therefore, the growth of wood may be reduced either by the removal of foliage, which reduces the working surface, or by shading, which somewhat checks the activity of the foliage by hindering light action.

Transpiration. The flow of sap in trees is not well understood. In a general way it may be said that the sapwood transmits the water from the roots to the leaves, where a part enters into the assimilated sap and goes to build up the plant, and the remainder, which is by far the greater part, passes off as vapor. The amount thus transpired varies greatly with the species, age of the tree, amount

of foliage at work, amount of light at its disposal, climatic conditions, and the condition of tree-growth. The amount of water transpired is so large in comparison to the amount retained in the tree that while an acre of forest may store in its trees 1,000 pounds of carbon, 15 or 20 pounds of mineral substances, and 5,000 pounds of water in a year, it may have taken from the soil and given off to the air from 500,000 to 1,500,000 pounds of water, or from one-quarter to one-half as much as agricultural crops. It has been estimated that the leaves of deciduous trees transpire one-sixth to one-third as much water as an equal surface of water. Large deciduous trees undoubtedly give off as much as a barrel of water a day in dry summer weather. Coniferous trees transpire much less water than most deciduous trees, frequently not over one-sixth as much.

Mineral Substances are taken up in small quantities and consist mostly of lime, magnesia, and potash. They are carried to the leaves, where they are used (perhaps also on their passage through the tree), with a part of the water, in food preparation. The main part of the mineral substances taken up remains as the water transpires in the leaves and young twigs and is returned to the soil when the leaves are shed and when the tree is cut and the brush left to decompose and make humus.

The Soil of Woodlands is Improved from year to year if the leaves and litter are allowed to remain on the ground and fire is kept out, since the mineral matters taken up by the tree are largely returned to the soil in a more soluble form and the amount of humus is increased. For this reason there is little need of alternating woodland crops.

Almost any soil can furnish a sufficient quantity of mineral substances for the production of a crop of trees, provided it is moist and the leaf mould is not removed. Good soils will continue to furnish mineral matter in suffi-

cient quantity, even if a portion of the leaf mould is carried away. If, however, this removal is continued annually for a long period, any but exceedingly fertile soils are likely to become exhausted, just as land on which field crops are grown cannot produce crops forever without manuring.

The Yearly Round of Life in a Tree. In the spring the tree starts into growth and feeds on the plant-food stored up the preceding year; the leaves unfold and commence furnishing plant-food. These two sources of food push the growth along very rapidly in the spring and early summer. By the first of July the food stored up the previous season is exhausted in many trees, and growth is entirely dependent upon the food furnished by the leaves. The growth at this time is generally much slower than in the spring, and as the capacity of the tree for building up plant-food increases, it commences to store up starch, sugar, and other foods in its cells with which to start growth the following spring, and the cell-walls become thicker and firmer. This maturing of the tree is termed *the ripening of the wood*, and when completed the tree is ready for winter. The hardiest trees generally ripen their wood early in the autumn and then cease growing, although probably some food is being stored up so long as the leaves remain green on the trees.

The amount of growth in a tree is shown in the amount of wood formed. A cross-section of a trunk or branch will show the growth each year by the thickness of the yearly rings. On close examination of the cross-section of an oak and many other trees it will be noticed that each ring is made up of two very distinct kinds of tissue and that one portion is very loose and open and the other very close and hard. The loose and open wood was formed during the rapid growth of spring and early summer and is termed spring wood. The dense, firm wood was formed during

the summer when the growth was slow. It is termed summer wood. (See page 161.)

Rest Period of Plants. With very few exceptions all plants require an occasional rest period for their best development. Some species get it naturally by being dried and others by being frozen. And even when plants are kept under growing conditions the year round they have periods of rest and of excitement. During the rest period the plants undergo very few changes, and yet there is undoubtedly some growth during mild weather in winter, and, as evaporation must be going on most of the time from twigs and buds, water must be supplied from the roots.

The Amount of Water Lost by Trees in Winter. After many careful experiments, A. L. Knisely, M.S., concludes that a Soft Maple standing 30 or 35 feet high with a trunk 15 to 18 inches in diameter near the ground, exposing from 750 to 800 square feet of bark surface, may lose daily by evaporation from 6 to 7 pounds of water when dormant. An Apple-tree 30 years old and 15 inches in diameter at the base, exposing from 800 to 1,000 square feet of bark surface, may lose daily while dormant from 10 to 13 pounds of water. These figures are from results obtained during winter weather in New York, where the relative humidity of the air is higher than in Minnesota, which would lessen evaporation. It is probable that during the winter evaporation is much more rapid in Minnesota and the Dakotas than it is in New York, which will partly, at least, account for so much loss in those sections by winter killing.

We know that after a prolonged period of severely cold weather the twigs of Soft Maple, Apple, and some other trees, have a decidedly shrivelled appearance which disappears after a few days of mild weather. Soft-Maple trees standing on dry land will sometimes in the spring appear to have been dried out and to have become partly or entirely dead. It is probable that during the coldest weather very

little, if any, moisture can be supplied from the roots, which may account for this shrivelled condition.

Second Growth. Sometimes warm, moist weather in late autumn will cause trees to start a strong second growth in October, which draws on the stored plant-food and perhaps exhausts it, and winter sets in before the tissues have again become hard and stored with food. In such cases trees are liable to injury. No characteristic of hardiness is more important in plants than that of early maturity of wood.

One part of the tree may start into growth without regard to the conditions of the other parts. For instance, a branch brought into a warm room in winter, without severing it from the tree, will grow for some time. Sun scald is probably due to the bark on the side most exposed to the sun starting into growth very early, after which a sudden freeze destroys the young cellular tissue.

CHAPTER II.

THE FOREST.

Arboriculture is a term that is applied to the growing of trees for any purpose whatsoever, whether singly or in groups.

Sylviculture is simply a synonym of the term forestry and is applied to the growing of trees in groups or forests.

Forest is a Term variously applied in this country. As here used, it applies to all collections of trees except such as are grown for fruit. It may, then, apply to a piece of land on which seedlings have only recently been planted, or to what is termed brush plan, or to land heavily stocked with trees.

TREE-GROWTH AFFECTED BY LIGHT CONDITIONS.

So Important is Sunlight to the Growth of Trees that it is sometimes said to be the purpose of trees to convert sunlight into wood. Practically all trees make their most rapid growth in full sunlight. There is, however, quite a difference in the power of various trees to get along with small amounts of direct sunlight. It is the object of good forestry to grow as much good timber as possible upon the land, just as good agriculture consists in growing the largest amount of farm crops upon the land. An acre of land covered with trees of the same species, it is estimated, will lay on the same amount of woody fibre whether the stems are large or small, the amount of wood formed each year being in direct ratio to the amount of foliage covering the land that is in good active condition.

It is known that some trees will do very well in the shade of other trees. This gives a chance to grow trees in a sort of two-storied fashion, having the land nearly covered with the foliage of one set of trees which require the full exposure to sunlight, and underneath, the land covered with the foliage of trees which will endure the shade of those above them, just as pumpkins can be grown under corn. On account of this peculiarity of trees, foresters have divided them into two classes, one of which is called **light-demanding** and the other **shade-enduring.** The words tolerant and intolerant are also used as distinguishing the peculiarity of trees in this respect, and they are perhaps better terms. Trees that are known as **tolerant** generally have a thicker mass of foliage than those that are **intolerant** of shade. This simply means that their lower leaves can withstand the shade of their upper leaves. While it is not an absolute rule that tolerant species have a thick mass of foliage and intolerant trees open foliage, yet it is so generally true that where this characteristic of a tree is known it serves as a very reliable indication. Most trees are much more tolerant of shade when young than when old. Among our tolerant trees may be mentioned the Spruce, Oak, Balsam, White Cedar, Red Cedar, Hornbeam, and Hard Maple. Among our intolerant species are Poplars, Cottonwood, Willows, Soft Maple, and Birch. Of our native pines, the White Pine is much more tolerant than either the Jack or the Norway Pine, which are quite intolerant of shade and soon succumb if they are protected from the full sunlight.

Trees Protect One Another and are Mutually Helpful, and many trees that are quite hardy on the limits of their growth when grown in groups, will fail if grown singly, as for instance the Hard Maple in exposed parts of Minnesota. Trees also interfere with one another and struggle for light and soil conditions, and the weaker trees are destroyed. So true is this that where the land is thickly seeded with even-

aged trees, they may all become weak and sickly because of hindering one another. On the other hand, this crowding of trees forces them to take on an upward growth and kills out the lower branches. Trees growing under such conditions make long timber free from knots, which is therefore most valuable.

SOIL CONDITIONS.

Water Supply. Water is the most important element in soils for tree-growth, and the greatest attention must be given to its conservation and distribution through the soil. Trees do not grow to best advantage in very wet or in very dry soil, although some can live and almost thrive under such unfavorable conditions. There is very little land, except in the arid region, but that will support some form of tree-growth. The soil best adapted to all kinds of trees is one that is moderately but evenly moist, porous, deep, and well drained; yet with a subsoil compact enough to transmit the subsoil water from below upwards without its being so solid that it cannot be easily penetrated by the roots. It does not matter about its being stony if it has these qualities. On land that is very wet, as the muskegs of Northern Minnesota, which are covered with Tamarack and Spruce, the trees never get to be of large size. In the case of one Spruce grown on such land, 73 years was occupied in growing a tree $1\frac{1}{8}$ inches in diameter, and a Tamarack under similar conditions formed a diameter of only $1\frac{1}{10}$ inches in 48 years. We also find that growth is extremely slow on very dry land. On very open porous land the water sinks quickly out of reach of the roots, and where the soil is too compact it cannot be penetrated by the water or by the roots, so that on such soils trees generally suffer for moisture a part of the year.

Relation Between Trees and Soils. The growth of trees and the kinds growing on land are good though not infalli-

ble indexes to the value of the soil for agricultural purposes. For instance, land on which Black Walnut, Hard Maple, Hackberry, or Hickory grow to large size is of good quality, for grasses, grains, and other agricultural crops, while Black Oak is generally abundant on dry, gravelly ridges and sandy soil. Where White Pine in Minnesota and Wisconsin is the prevailing tree, the land is generally of good quality. Norway Pine will endure more drought than the White Pine, outgrows it, and becomes the prevailing tree on drier land there, while the Jack Pine is the most abundant on the very dry sandy lands. In the more humid climate of the Eastern States, the White Pine grows on very sandy soils.

Mechanical Condition of Land in Forests. The agriculturist aims to keep the soil porous, yet moderately compact, that the roots may penetrate it easily and the subsoil waters may be readily transmitted upwards to the roots of plants. He aims to prevent the soil from becoming too compact and the loss of water from evaporation by cultivating the surface soil, and to keep out standing water by drainage. The forest-grower cannot rely upon such methods, because they are too expensive or entirely impracticable. He may indeed plough for his first planting and cultivate the young trees, but after a few years cultivation will become impossible and the effects of the first preparation will be lost. He must therefore attain his object in another way, that is, by mulching the soil. The shading is done at first by planting very closely, so that the ground may be protected as soon as possible from sun and wind. The shade should be maintained well throughout the life of the tree, even if more planting is necessary to accomplish it, and if in later life the trees get thin in the tops or die out, it may become necessary to plant underbrush to protect the land.

Undergrowth in Forests may be rather injurious in preventing the proper development of young trees, but it is

generally very beneficial in retarding evaporation from the surface soil, in retaining the snow in the spring, and in killing out grass and weeds.

Forest Floor is a term used to indicate the mulch on the ground in forests. This is made up of the fallen twigs and leaves which remain on the ground, where they slowly decay and form a cover of rich mould or humus. This protective covering serves a most useful purpose; it permits the rain and snow waters to penetrate the soil without at the same time making it too compact, thus keeping the soil granular so that the air can enter, and in the best condition for conducting water, while at the same time it prevents washing away of the land and too rapid or excessive evaporation from the surface; the humus is also an active agent in aiding decomposition of the mineral substances in the soil.

Subsoil. Tree-growth is less dependent on the condition of the surface soil and more dependent on the subsoil than is the growth of agricultural crops. For instance, in the case of drifting sand overlying a moist subsoil, it has been found that where pains are taken to get the young trees started they will often do well although such land is poorly adapted to agricultural crops. There are many acres of land in our Northern States that have such conditions, and they should seldom be entirely cleared of trees.

Washing of Soils. The soils most likely to wash badly are those that are fine-grained without much adhesive power, such as fine sand and some kinds of clays. When, however, such soils have a forest growth on them, they are protected from washing by the forest floor, tree roots, and the humus in the soil. Soil which contains large quantities of humus does not wash much, since the particles of organic matter bind it together; thus we find that newly cleared timber land which contains large amounts of humus may not wash much for a number of years after the clear-

ing, and then commence to wash very badly. The washing away, then, is due to the humus having become used up and there being nothing left to bind the soil particles together. In such cases the application of organic matter will help very materially. For this purpose manure, straw, or other material may be applied, or crops like clover and the grasses, which leave considerable organic matter, may be grown on the land. Crops that leave very little humus in the ground, such as nursery stock, which is dug out by the roots, are most harmful in exhausting the humus in the soil, and land used for this purpose needs heavy manuring with stable manure and an occasional seeding down to grass or clover.

Alkali Soils. In the prairie portions and occasionally elsewhere we have a kind of soil in which there is a superabundance of carbonate and sulphate of soda. This kind of soil seldom extends over large areas and generally occurs in places lower than the surrounding land. In some places the alkali occurs in such abundance as to coat the surface of the soil with a white crust. On such land very few agricultural crops or trees grow well. The leaves of the trees growing there generally take on a yellowish color and the wood does not mature well in the autumn. Such land should be drained so that the surface water at least can run off. In this way the alkali can generally be washed out in a few years. It is seldom advisable to plant trees on these places, but if this seems desirable, as is sometimes the case on prairies, the best trees to plant are probably the Cottonwood and White Willow.

EFFECT OF SLOPE AND ASPECT ON TREE-GROWTH.

The slope of the land affords drainage and so affects the growth of trees, but trees will grow on any slope, even on precipices, if they can find room for their roots and the soil is somewhat moist. The direction of the slope usually

has a very marked effect on the growth of vegetation. This is especially the case where high ranges of hills and other local conditions modify the climate.

A Northern Slope receives no full sunlight; the sun's rays fall obliquely in the morning or toward evening, according to the angle of elevation. The winds it receives in winter are colder than those received by the southern slope, but the few winds which strike it during the growing season are not strong, hot, or very dry. As the vegetation is a little delayed on a northern slope, there is less danger from late spring frosts than on a sunnier aspect, and as the snow melts slowly, there is a better chance for its waters to soak into the ground. In consequence of these facts trees are less liable to suffer from drought on the same kind of land with a northern than with a southern exposure. The trees keep a more regular form and growth is more uniform and certain. It will generally be found that where timber is cut off from a northern slope growth renews itself very quickly, for tree seeds are most likely to grow under the conditions found there.

An Eastern Slope receives the sun in the cool morning hours when the temperature and light are moderate. It is not exposed to hot, dry winds nor to the intense heat of the sun. The soil retains its moisture fairly well and trees make a good growth. For trees it ranks next in value to a northern slope.

A Southern Slope receives the most direct rays of the sun and the full force of hot, dry winds and beating rains during the growing season. Consequently vegetation is more liable to injury by late spring frosts, because of starting earlier in the spring, than in any other location. The soil is most liable to erosion from beating summer rains and dries up most quickly after the spring rains. The trees grow irregular in form, the seeds seldom start well on southern or western slopes, and when once cleared, tree-

growth is often difficult to renew. As proof of the importance of these conditions as affecting tree-growth we have the commonly observed fact that the south and west sides of steep hills and mountains are more likely to be bare than any others. This can be very plainly seen on the bluffs along the Mississippi River in Minnesota and Iowa.

A Western Slope receives the sun's rays obliquely, but in the warmest part of the day gets the full force of the hot dry southwest winds which are so common in many parts of this country. The effect of such an exposure on growth is about the same as the southern slope. On the mountain ranges of the Pacific slopes of North America, the western exposures receive the most rainfall and consequently have the heaviest tree-growth.

CHAPTER III.

FOREST INFLUENCES.

Upon careful observation it will be found that a single large spreading tree growing in an open field appreciably affects climatic and soil conditions in the following ways:

1. *During the day the ground under a tree* is protected from the sun's rays and is therefore cooler than soil not protected. As a result of this protection, the air under the tree is cooler than the air in the open, and, as it is constantly in circulation, tends to cool the air in the immediate vicinity of the tree on sunny days.

2. *At night a tree retards the radiation of heat* from the ground under it. This tends to equalize the temperature of not only the soil and air under the tree, but that in the near vicinity. Therefore, though a tree may reduce the temperature of the soil and air on sunny days or during a short period of warm weather, it may, on the other hand, increase the temperature at night or during a short period of cool weather. For example it may be noticed that vegetables growing near trees are frequently uninjured by autumn frosts which destroy those growing in the open.

3. *A tree aids in retaining water in the surface soil* to the leeward by breaking the force of the wind, and thus retarding evaporation, for it is known that evaporation increases with the rapidity of the air-currents. It retains the water in the surface soil under the tree by shading the soil and thus retarding evaporation. The large amount of water which is transpired by a tree is largely drawn from the subsoil,

and this increases the humidity of the surrounding air without drawing on the water of the surface soil. But some kinds of trees take up so much of the water from the soil as to preclude the growing of crops in such places near them.

4. *The leaves that fall to the ground form a mulch* which prevents the drying out of the soil. They check the flow of water over the land, thus preventing the washing away or compacting of the soil by heavy rains, and giving the water a better chance to soak into the ground.

5. *A tree protects from the destructive force of severe winds.* A single tree or group of trees may seem to have little effect on tornadoes, but large groups of trees may possibly prevent their formation or greatly lessen their violence. Protection from severe winds may greatly affect the growing of plants, since, on account of the winds, many plants that may be successfully grown when protected by shelter-belts cannot be grown on the open prairie. This protection, when present, serves to lessen the fuel necessary to warm dwelling-houses and also lessens the food eaten by animals. It also keeps the surface soil in fields from being blown away.

In these five principal ways a single tree affects the conditions of climate and soil in its immediate vicinity. To be sure, some of them are not so very evident where a single tree grows in an open field, but where trees are growing in groups or on large tracts of land all of these factors are important in modifying climate and soil conditions, and will be referred to at greater length.

INFLUENCE OF FORESTS ON WATER SUPPLIES.

It is very evident that the proper disposition of water upon the land is the most important factor in the growing of crops, and it is equally evident that nature's changeful and wasteful ways of supplying water to crops are not the best

ways of so doing, for we know that not only in the arid regions, but in general wherever irrigation is used, crops are produced in greatest abundance and certainty. This once recognized, then the proper distribution of the available water supplies becomes a question of immediate interest. Human effort can, to a limited extent, direct the laws of nature that influence climate and soil conditions, and it becomes necessary that we have a clear understanding of the forces that are at work in nature in order that we may know where we may or may not expect to be successful in directing them. In order that we may better understand this subject, I quote the following extract on forest influences from the report of the Forestry Division of the U. S. Department of Agriculture for 1880, with a few changes in the nature of abbreviations:

"The water capital of the earth may be regarded as consisting of two parts, the fixed capital and the circulating capital. The first is represented, not only in the waters on the earth, but also by that amount of water which remains suspended in the atmosphere, being part of the original atmospheric water-masses which, after the rest had fallen to the cooled earth, remained in suspension and is never precipitated.

"The circulating water capital is that part which is evaporated from water surfaces, from the soil, from vegetation, and which, after having temporarily been held by the atmosphere in quantities locally varying according to the variations in temperature, is returned again to the earth by precipitation in the form of rain, snow, and dew. There it is evaporated again, either immediately or after having percolated through the soil and been retained for a shorter or longer time before being returned to the surface, or, without such percolation, it runs through open channels to the rivers and seas, continually returning in part into the atmosphere by evaporation. Practically, then, the total amount

of water capital remains constant; only one part of it—the circulating capital—changes, in varying quantities, its location, and is of interest to us more with reference to its local distribution and the channels by which it becomes available for human use and vegetation than with reference to its practically unchanged total quantity.

"As to the amount of this circulating water capital we have no knowledge; hardly an approximate estimate of the amount circulating in any given locality is possible with our present means of measurement; for it appears that so unevenly is the precipitation distributed that two rain gauges almost side by side will indicate varying amounts, and much of the moisture which is condensed and precipitated in dews escapes our observation, or at least our measurements entirely. Thus it occurs that while the amount of water calculated to be discharged annually by the river Rhone into the sea appears to correspond to a rainfall of 44 inches, the records give only a precipitation over its watershed of 27.6 inches.

"We must therefore enter into our discussions acknowledging ignorance of one of the most important factors, at least as to its numerical or quantitive value.

"The distribution of the circulating water capital is influenced by various agencies. The main factor which sets the capital afloat is the sun, which, by its heat, and the air-currents caused by it, and by the rotation of the earth, produces the evaporation which fills the atmosphere with vapor. Anything, therefore, that influences the intensity of insolation, the action of the sun, or obstructs the passage of winds, must influence the local distribution of the water capital. The great cosmic influences which produce the variability of all climatic conditions, and therefore also of the circulating water capital, are the position of the earth's axis to the sun, by which the angle and therefore the heat value of the sun's rays vary in different parts of the

earth and at different times of the year; the distribution of land and water areas, which produces a difference of insolation because the water has more heat capacity than the land, and which also influences the direction of air- and sea-currents; the configuration of the earth, by which the density of the atmosphere is made unequal, and in consequence of which differences of insolation and of air temperature are induced. Thus we have not only climatic zones, but also continental climates and mountain climates in opposition to coast climates and plain or valley climates.

"While this classification of cosmic climates satisfies the climatologist, there are many local climates to be found within the range of the cosmic, and the local climatic conditions are those which affect human life and human occupations most sensibly.

"The same causes, different only in degree, which modify the cosmic climates, making a classification of the same possible, effect further modifications and give rise to local climates; these causes are different in the degree of insolation, obstruction to air-currents, presence of water surfaces, or moisture-laden air strata.

"Among the factors which thus modify the cosmic climate and help to produce a local climate differing from other local climates, the soil cover, and especially the presence of forest areas, is claimed as one that, under certain conditions, is potent: and this factor, being under the control of human agency more than any other possible modifier of climate, must therefore be of greatest interest to us. It is clear, from what has been stated so far, that the influences of the forest, if any, will be due mainly to its action as a cover protecting the soil and air against insolation and against winds. That the nature of a cover, its density, thickness, and its proper position has everything to do with the amount of protection it affords, everybody will admit. A mosquito-net is a cover, so is a linen sheet or a woollen blan-

ket, yet the protection they afford is different in degree and may become practically none. It will also be conceded that it makes a great difference whether the cover be placed before or behind the wind. Just so with the influence of the forest; it makes all the difference whether we have to do with a deciduous or coniferous, a dense or an open, a young low or an old high growth, and what position it occupies with reference to other climatic elements, especially to prevailing winds and water surfaces. In the following discussions, when the word forest is used, unless differently stated, a dense growth of timber is meant.

"The question of forest influences on water supplies can be considered under three heads, namely—influence upon precipitation or distribution of atmospheric water; influence upon conservation of available water supplies; influence upon the distribution or 'run-off' of these supplies.

INFLUENCE UPON PRECIPITATION.

"Whether forest areas are or are not capable of appreciably increasing precipitation within their limits or on neighboring ground is still a matter of dispute, and the complexity of the elements which must enter into the discussion has, so far, baffled solution based upon definite and strictly scientific observation. Yet new evidence is accumulating all the time which apparently shows that under certain conditions forest areas obtain larger precipitations than open grounds, that is, they may increase at least the amount of precipitation over their own immediate and near-lying areas.

[In Minnesota, popular opinion inclines to the belief that there is a close connection between the existence of forests and the rainfall of this section, and that, with the disappearance of our forests, will come a much more rigorous climate and a decrease in rainfall. But the records of the

weather bureau do not show that there is any connection between the two or that there has been any apparent change in the general climate or amount of rainfall due to the removal of our forests. The flow of water in most of our rivers, and in many cases, the flow of water from springs, and the height of the water table in the land, have been most seriously affected by the removal of our forests and should be regarded as the ways by which our water supply is to suffer most severely from deforestation.]

DISPOSAL OF WATER SUPPLIES.

"Given a certain amount of precipitation in rain or snow over a certain area, the disposal of the water after it has fallen, and the influence of the forest cover on its disposal, require our attention. For the sake of convenience we can divide the elements which need consideration in this discussion into elements of dissipation, elements of conservation, elements of distribution.

"The difference in effect between the first two classes of elements will give us an idea of the amount of available water supply or run-off resulting from precipitation, while the third class bears upon the methods of distributing the available water supply.

ELEMENTS OF DISSIPATION.

"Elements of dissipation are those which diminish the available water supplies; they are represented in the quantity of water which is prevented by interception from reaching the ground, in the quantity dissipated by evaporation, in the quantity used by plants in their growth, and in that used by transpiration during the process of growing.

"**Interception.** The amount of rainfall and snow which is prevented by a forest from reaching the soil varies considerably according to the nature of the precipitation and

to the kind of trees which form the forest, as well as the density and age of the growth.

"A light drizzling rain of short duration may be almost entirely intercepted by the foliage and at once returned to the atmosphere by evaporation; if, however, the rain continues, although fine, the water will run off at last from the foliage and along the trunks.

"Altogether for the rainfall conditions of Austria, Prussia, and Switzerland, where measurements have been made, a dense forest growth will on the average intercept 23 per cent. of the precipitation; but if allowance be made for the water running down the trunks, this loss is reduced to not more than 12 per cent.

"The amount of interception in the open growths which characterize many of our Western forest areas would be considerably smaller, especially as the rains usually fall with great force, and much of the precipitation is in the form of snow. Although branches and foliage catch a goodly amount of this, the winds usually shake it down, and consequently but very little snow is lost to the ground by interception of the foliage.

"There is also a certain amount of water intercepted by the soil cover and held back by the soil itself, which must be saturated before any of it can run off or drain away. This amount, which is eventually dissipated by evaporation and transpiration, depends, of course, upon the nature of the soil and its cover, especially upon their capacity to absorb and retain water.

"The water capacity of litter depends upon its nature and of course its thickness to a certain degree, but is much greater than that of soils.

"Altogether an appreciable amount of the precipitation does not run off or drain through the forest cover, but is retained by it; yet, while this is apparently a loss, we shall see further on that this moisture retained in the upper strata

fulfils an important office in checking a much greater loss due to evaporation and thus becomes an element of conservation."

Evaporation. The loss by evaporation after the water has reached the ground depends in the first place upon the amount of direct insolation of the soil, and hence its temperature, which again influences the temperature of the air. The nature of the soil cover, the relative amount of moisture in the atmosphere, and the circulation of the air are also factors determining the rate of evaporation. The importance of evaporation as an element of dissipation may be learned from the experiments of Prof. T. Russell, Jr., of the U. S. Signal Service, made in 1888. We learn from these that the evaporation on the Western plains and plateaus may, during the year, amount to from 50 to 80 inches, nay, in spots, 100 inches, while the rainfall (diminishing in reverse ratio) over this area is from 30 to 12 inches and less.

"Thus, in Denver, where the maximum annual precipitation may reach 20 inches, the evaporation during one year was 69 inches. This deficiency of 49 inches naturally must be supplied by waters coming from the mountains, where the precipitation is large and the evaporation low. (On Pike's Peak alone there may be 45.6 minus 26.8 or 18.8 inches to spare.)"

Evaporation from the soil is dependent upon its covering, and this is important, as the soil in forests is always covered with dead branches, leaves, etc. In some experiments which were carried on in Germany during the months of July and August, 1883, to determine the amount of evaporation from different soils, it was found that from 1,000 square centimeters of bare ground, 5,730 grams of water were evaporated, and that from the same area of similar soil covered with two inches of straw, 575 grams were evaporated. This shows that the naked soil evaporated more than ten times as much as the covered soil. It is

evident, then, that the soil covering has an important function in preventing evaporation.

Wind-breaking Power of Forests. If the loss by evaporation from an open field be compared with that of a forest-covered ground, as a matter of course it will be found to be less in the latter case, for the shade not only reduces the influence of the sun upon the soil, but also keeps the air under its cover relatively moister, therefore less capable of absorbing moisture from the soil by evaporation. In addition, the circulation of the air is impeded between the trunks, and this influence upon available water supply, the wind-breaking power of the forest, must be considered as among the most important factors of water preservation. Especially is this the case on the Western plains and on those Western mountain ranges bearing only a scattered tree-growth, and where, therefore, the influence of shade is but nominal.

The evaporation under the influence of the wind is dependent, not only on the temperature and dryness of the same, but also on its velocity, which being impeded, the rate of evaporation is reduced.

Interesting experiments for the purpose of ascertaining the changes in the rate of evaporation effected by the velocity of the wind were made by Prof. T. Russell, Jr., of the Signal Service, in 1887. The result of these experiments (made with Piche's hygrometers whirled around on an arm 28 feet in length, the results of which were compared with those from a tin dish containing 40 cubic centimeters of water exposed under shelter) show that, with the temperature of the air at 84 degrees and a relative humidity of 50 per cent., evaporation at 5 miles an hour was 2.2 times greater than in a calm; at 10 miles, 3.8; at 15 miles, 4.9; at 20 miles, 5.7; at 25 miles, 6.1, and at 30 miles the wind would evaporate 6.3 times as much water as a calm atmosphere of the same temperature and humidity.

Now, if it is considered that the average velocity of the winds which constantly sweep the Western subarid and arid plains is from 10 to 15 miles, not rarely attaining a maximum of 50 and more miles, the cause of the aridity is not far to seek, and the function of the timber belt or even simple windbreak can be readily appreciated.

Professor King has found in experiments made in Wisconsin that the influence of even a thin stand of woodland on the rate of evaporation was considerable. In one experiment made in the month of May, the instruments were so placed as to measure the evaporation to the leeward of a scant hedgerow six to eight feet high, having in it a few trees twelve feet high and many open gaps. It was found that at 300 feet from the hedge the evaporation was 30.1 per cent. greater than at 20 feet, and at 150 feet it was 7.2 per cent. less than at 300 feet. The experiment was made during a moist north wind. It is sufficiently evident, therefore, that even a thin hedgerow exerts an influence that can readily be measured. In fact the presence or absence of protecting belts of trees under the conditions often existing on our prairies may make a difference between a good and a poor crop. All who are acquainted with our prairie sections know that great damage is often done to wheat, corn, and other crops by the hot southwest winds which we are likely to have during the growing months. In Kansas and Nebraska, during the summer of 1894, immense tracts of corn, fully tasselled out, were killed by such winds. At the same time it was noticed that where corn was protected by trees or slopes of land, or where the humidity of the wind was increased by passing over bodies of water or clover fields, the injury was greatly lessened.

What the possibilities of evaporation from hot and dry winds may be can be learned from statements regarding

the "Fœhn," which is the hot wind of Switzerland, corresponding to the "chinook" of our Western country.

The change in temperature from the normal, experienced under the influence of the Fœhn, has been noted as from 28 degrees to 31 degrees Fahr., and a reduction of relative humidity of 58 per cent. A Fœhn of twelve hours' duration has been known to "eat up" entirely a snow cover 2½ feet deep.

In Denver a chinook has been known to induce a rise in temperature of 57 degrees Fahr. in twenty-four hours (of which 36 degrees in five minutes), while the relative humidity sank from 100 to 21 per cent.

The degree of forest influence upon rate of evaporation by breaking the force of winds is dependent upon the extent and density of the forest, and especially on the height of the trees; for according to an elementary law of mechanics the influence which breaks the force of the wind is felt at a considerable elevation above the trees. This can be practically demonstrated by passing along a timber plantation on the wind-swept plains. Even a thin stand of young trees not higher than five feet will absolutely calm the air within a considerable distance and height beyond the shelter.

Professor King found that an oak grove 12 to 15 feet high exerted an appreciable effect in a gentle breeze at a distance of 300 feet. In a strong wind the effect of such a grove would be felt at a much greater distance to the leeward.

At the Dominion Experiment Station in Assiniboia, Dr. Saunders found on one occasion that windbreaks exerted an appreciable influence at from 50 to 80 feet to leeward for every foot in height, but this was during a very severe wind. It may probably be laid down as a general rule that windbreaks will exert an appreciable influence for at least one rod for every foot in height.

It may not be necessary to state that the damage done to crops by the cold, dry, winter winds is mainly due to rapid

evaporation, and that plants are liable to suffer as much by winter drought as by summer drought.

This is certain: that since summer and winter drought—that is, rapid evaporation due to continuous dry winds—is the bane of the farmer on the plains, rationally disposed timber belts will do much to increase avaliable water supply by reducing evaporation.

Evaporation, of course, goes on much less rapidly within than without the forest. How great this difference is we have no exact figures to tell, but it is certain that it is much more than in Bavaria, where the following result was obtained: In an experiment, which was carried on to determine the amount evaporated from April to October, it was found that from a certain area without the forest 40.8 centimeters were evaporated, within pine wood 15.9 centimeters, and within deciduous woods 6.2 centimeters. This shows that the evaporation was six and one-half times as great in the open field as in deciduous woods.

Transpiration. Another factor by which forests dissipate water supplies and which has been referred to (page 8) is transpiration. The quantity of water so used is as variable as the amount of precipitation, and in fact, within certain limits, depends largely upon it; that is to say, a plant will transpire in proportion to the amount of water which is at its disposal. Transpiration is also dependent on the stage of development of the plant, on the nature of its leaves and amount of foliage, on temperature, humidity, and circulation of the air, on intensity of the sunlight, and on temperature and structure of the soil, and on other meteorological conditions. Rain and dew reduce transpiration, wind increases it.

The amount of transpiration depends considerably upon the thickness of the leaves; therefore the surface of the foliage is not a reliable measure, but should be compared with the weight.

In some European experiments carried on during the period of vegetation, the amount of water transpired by the different species per pound of dry matter in the leaves was as follows:

	Pounds of Water.
Birch and Linden	600 to 700
Ash	500 to 600
Beech	450 to 500
Maple	400 to 450
Oak	200 to 300
Spruce and Scotch Pine	50 to 70
Fir	30 to 40
Black Pine	30 to 40
Average, deciduous trees	470
Average, evergreen trees	43

This shows that there is a great difference in the amounts of water transpired from deciduous trees and evergreen trees. In this case the deciduous trees transpired about eleven times as much as the evergreens.

The variability of transpiration from day to day is of wide range; a birch standing in the open and found to have 200,000 leaves was calculated to have transpired on hot summer days 700 to 900 pounds, while on other days its exhalations were probably not more than 18 to 20 pounds.

But while trees transpire large amounts of water, our agricultural crops and other low vegetation transpire much larger amounts to the same areas. A small factor in the dissipation of water supplies is the amount of water that is retained in the plant itself. As before mentioned, this may amount annually to about 5,000 pounds per acre. The water in fresh-cut woods forms a large part of their weight. In hard woods, such as Ash, Oak, Elm, and Birch, it forms 38 to 45 per cent., and in soft woods 45 to 55 per cent. or more.

ELEMENTS OF CONSERVATION OF WATER SUPPLIES.

In discussing the elements of dissipation as to the degree of their effect under forest cover as compared with the same elements at work in the open field, we have seen that the shade, the low temperature, the relative humidity, the absence of strong air-currents, and the protective and water-holding capacity of the forest floor are all factors in the conservation of the water supplies. We have also seen that the quantity of water lost by evaporation, the greatest source of dissipation, may be more than six times as great in the open as in the forest. The only other conservative effect of forests on water supplies is their effect in retarding the melting of the snows. This acts as an important function in the prevention of freshets by giving the snow a longer time to melt, so that the snow water has a better chance to sink into the ground. It is of course more evident in evergreen than in deciduous forests. On the grounds of the Minnesota Experiment Station, where the woodland consists of a low growth of Oak, the snow is often retained in the woods a week longer than in the open. This often allows the snow water from the fields to almost wholly run off before it has begun to flow from the woods. Then again the daily flow of snow water from the woods is much shorter than from the open fields during spring weather when we have warm days and cold nights, for it begins later in the morning and stops earlier in the afternoon. Under the dense shade and mulch of the cedar swamps of Northern Minnesota, the snow and ice often remain until the beginning of summer. The Indians claim there has never been a time when they could not find ice for their sick in the cedar swamps of that section. This retarding effect on the melting of snows in the spring and in preventing the run-off is of far greater importance in the case of streams that rise in the high mountains than in Minne-

sota and Wisconsin, where the land is more nearly level. Where streams have their sources in mountains, as those of Colorado and other Rocky Mountain States, the cutting away of the forests causes a heavy flow of water early in the spring and little water in the summer, when it is most needed for irrigation purposes. This has become so evident that the Chamber of Commerce of Denver, Colorado, recently petitioned the President of the United States to reserve such land in forests and administer it at public expense, and in their petition used in part the following language:

"The streams upon which the irrigation system of Colorado depends are fed by the springs, rivulets, and melting snows of the mountains, which in turn are nourished and protected by the native forests. Where the forests have been destroyed and the mountain slopes laid bare, most unfavorable conditions prevail. The springs and the rivulets have disappeared, the winter snow melts prematurely, and the flow of the streams, formerly equable and continuous, has become fitful and uncertain. Floods and drought, alternating clearly, indicate that the natural physical conditions of the region have been unduly disturbed. In winter and early spring, when heavy masses of snow have been accumulated on treeless precipitous slopes, snow- and landslides frequently occur with disastrous result to life and property."

THE DISTRIBUTION OF WATER.

The distribution or "run-off" of the water is often a more important factor in its economy than the quantity available. It is influenced by the surface conditions of the soil cover, by the porosity and structure of the soil, and by the slope. There are two kinds of run-off—the surface run-off and the underground run-off or percolation. The former is likely to do injury by eroding the soil, while the

latter is generally beneficial to vegetation in the formation of springs and in raising the water level in the soil. It is evident that the less surface drainage and the more underground drainage there is, the greater the spring-water supply, and vice versa. We are, therefore, interested in determining the factors that increase underground drainage and reduce the surface flow.

It is plain that whatever retards the flow of water over the land, aids it in sinking into the soil. We find this exemplified in swamps, where the soft, rough ground retards the surface flow, and in forests, where the foliage checks the water in its descent to the ground and the forest floor retards the surface run-off. Theoretically, such a cover should promote the flow of springs and maintain the height of water in wells, and in practice we find that this is often the case. In some cases, springs had entirely disappeared after the clearing of near-by forests, but have commenced their regular flow since the trees have been allowed to grow again. Springs in turn influence the flow of water in rivers, so that forests about the headwaters of streams often have a most potent effect in maintaining their flow. There is in fact no influence of the forest that is of greater importance in the distribution of water supplies than its effect in retarding the run-off, even though its effect in preventing evaporation is very important.

FOREST INFLUENCES ON WIND- AND HAIL-STORMS.

We have seen that the wind-breaking power of the forest is a very important factor in retarding evaporation, and in preventing the drifting of sandy soil and snow. In the forest the air may be rather still, while in the open a piercing gale may be blowing; in consequence there are no blizzards in a wooded country. Tornadoes of great force have occasionally broken down wide areas of timber, but

instances are very rare in which they have continued for long distances through forests, and it is probably true that forests have a tendency to prevent their formation and perhaps entirely break up those of lesser violence. M. Becquerel is said to have found by careful study that in some parts of Central France hail-storms show a marked disinclination to enter forests, and yet occasionally they do so, but nothing of this sort has been noticed here.

FOREST INFLUENCES ON FOGS AND CLOUDS.

The influence of forests on fogs and clouds has frequently been mentioned. The fog seems to linger in the woods after it has cleared off elsewhere. Trees also act as condensers and gatherers of dew, hoar-frost, and ice; the latter phenomenon is especially remarkable in the so-called ice-storms, where the accumulation of ice on the trees is so great as to break them down. The load of ice on some large trees is probably a ton or more. In this case the tree acts simply as an inorganic body.

IMPROVEMENT OF LAND ON WHICH TREES GROW.

As has been shown, trees add large amounts of soluble mineral matters to the soil through the fall and decay of their leaves. In the same way they add large amounts of humus to the land, which helps to keep the soil porous and yet makes it more retentive of moisture and gases. The roots of trees often penetrate deep into the soil and bring up plant-food that would not be reached by agricultural crops. A part of this is returned to the surface soil by the yearly fall of the leaves and in the twigs and branches that are left on the ground when the tree is cut down. The roots deepen the soil, and by their decay furnish plant-food to the soil and leave channels through which water and air

may enter the subsoil. It has been estimated that after a sandy soil in New England is so exhausted that it will produce nothing but red mosses, it may be renewed to its pristine vigor and productiveness by the growth of trees on it for thirty years.

WHY THE PRAIRIES ARE TREELESS.

This question has been answered in many ways, but often, it would seem, by persons not acquainted with the principles of forestry. It seems that the best way of getting a clear understanding of this matter is to consider two extremes of tree-growth. Eastern Minnesota has a rainfall of perhaps 26 to 35 inches and a comparatively moist air, and at least during a part of the year is well adapted to the growth of the hardier kinds of trees. Here we find the White Pine, Basswood, Oak, Elm, Poplar, and other trees attaining large size. Western Dakota has a very light rainfall, mostly in the spring, and a very high rate of evaporation. Trees can scarcely be made to grow in this section without irrigation, and the low vegetation, the grasses, which require a less amount of water, replace the trees. It is evident that between locations having such extremes of tree-growth there must be a place where the trees give way to the lower forms of vegetation. Such a meridianal zone is found in Central Minnesota, and though it has probably changed with fluctuating rainfall, its general location has remained practically the same for many years. The location of this zone was probably gradually driven eastward, for many years previous to settlement, by the practice of the Indians of burning over prairies in order to furnish good pasturage for the buffalo. Of late years, since the prairie fires have been largely prevented, the tree line has moved westward and gained a little on the prairies. When left to itself, the western limit of this tree zone would not make

very great progress westward, but with man's assistance in cultivation and various other ways, it may be extended much farther towards the arid regions than if left to natural conditions. So we find that, while great sections of the interior of this country are treeless on account of lack of water, trees planted on them and properly cared for may often grow thriftily. But trees planted on our prairies always require more care to make them do well than those planted in sections of greater rainfall, and we should not expect them to grow as large as in the timbered sections without irrigation.

RAINFALL AND HEIGHT OF WATER TABLE IN THE LAND.

A few years ago it was argued by many friends of tree-planting that it was practicable by the planting of trees to increase the rainfall and prevent evaporation in the great continental plain sufficiently to materially change the climate. The large rainfall and the good crops produced for a number of years in the drier portions of this area, after considerable planting had been done, seemed to indorse all that the most enthusiastic of tree-planters claimed. But it must be very evident to any careful student of the subject that such small plantings as were made, even had they been maintained, could scarcely have had any appreciable effect on the general climate of so vast a territory. It is very evident, too, from a study of the annual rainfall, that it has fluctuated greatly in this section, and that we have perhaps not recorded the least or the greatest amount for any one year.

There are some facts that seem to show plainly that there must have been a time when the water-level of our lakes was much lower than it is now or than it was during the very dry years from 1890 to 1895, when the rainfall in

most cases produced no flow in the streams. There is a lake near Devil's Lake, N. D., where in 1890 the old overland trail leading west terminated abruptly on one side of the lake and was taken up again in the continuation of its direction on the opposite side. The trail is clear and distinct, showing it to have been of comparatively recent use. It is a reasonable inference that when this trail was in use, this lake was dry. There are places near the shores of Devil's Lake where upright stumps are standing submerged in water. The same phenomenon has been noticed in other places. These are almost certain indications of a time or times when the beds of these lakes, where the stumps are, were out of water or very nearly so for a sufficient length of time for the trees to grow. The climate must have been very dry, and the great continental plain, or at least portions of it, must have bordered pretty closely upon a desert, and the "Great American Desert" may have been a reality. It would seem, then, that the knowledge we are gaining of the unknown past, as well as the records of more recent years, point to the recurrence of great fluctuations in the annual rainfall of this section, and it seems probable that such changes follow series of years, and that the recedence of our lakes may be followed by periods of higher water.

But the influence of the cultivation of the soil on water supplies must be taken into account in this connection, for it is undoubtedly true that man has changed the conditions of the soil sufficiently to greatly influence the run-off. The breaking up of large areas of prairie sod, with its low rate of evaporation, and the planting of such land to agricultural crops with a relatively high rate of evaporation, has resulted in a loss of soil water. Then the cultivated soil takes up more water than the sod-bound prairie slopes, so that it does not have so good an opportunity to collect in lakes and swamps, which often supplied the water of wells. And

further, the straightening and cleaning out of watercourses, and the draining of swamps in the effort to get arable land, has had a similar effect on subsoil water supplies.

HOT WINDS.

The hot winds of the plains which so often cause serious injury to farm crops in Kansas, Nebraska, and the Dakotas have been ascribed to the arid "staked" plains, whence, taking a northeasterly direction, they draw all the moisture from the vegetation with which they come in contact. The view has also been presented that they have their origin on the Pacific Coast, ascend the Rocky Mountains, lose their moisture, and descend on the eastern slopes. But all theories that ascribe their origin to a distant source are inadequate to explain their phenomena. For instance, all who are acquainted with these winds know that they blow only during very dry weather, when the earth is heated very hot, that a good rain speedily brings them to an end, and that they blow only during the daytime, commencing about 9 A.M. and continuing until sundown. This daily movement is often constant for several weeks, showing that there is evidently some connection between them and the course of the sun. For these reasons and others which would require too much space to give here, the best authorities unite in attributing them to local origin.

Mr. George C. Curtiss describes the process of the production of a typical hot wind as follows: "The necessary conditions are those of the 'warm wave,' namely, a diminishing pressure to the northward, producing southerly winds which initially elevate the temperature above the normal. A cloudless sky favors an intense insolation, as a result of which the dry ground is soon raised to an extreme temperature, and the air is heated from it by radiation, reflection, and conduction. The resulting diminution of density due

to the rise of temperature furnishes impetus to previously existing horizontal currents, and by 10 o'clock in the morning the hot wind is fully developed. Hundreds of miles of hot dry earth contribute to maintain and feed the current, and, gathering strength as the sun mounts higher, the hot wind sweeps over the defenceless prairie. Neither hills nor forests rise in its path to break its power or dispute its sway, and, with no enemy save the tardy rain-cloud, the fetid blast sucks out the life-sap of the growing grain. It will be readily seen, then, that each of the States—Kansas, Nebraska, and North and South Dakota—develops its own hot winds and cannot charge them to the account of its neighbors."

The local origin of these winds at once suggests the desirability of frequent windbreaks on the prairie farms, as offering the most practical way of breaking them up. Irrigation of large areas will also undoubtedly do much to prevent them.

CHAPTER IV.

TREE-PLANTING ON PRAIRIES.

THE subject of tree-planting in this country naturally divides itself under the two heads of prairie-planting and forest-planting. The former relates to the limited planting of trees on our prairies for ornament, protection, and use, and the latter to the care and management of timber lands and the planting of trees for profit from their growth. Our people are very generally impressed with the importance of prairie-planting for protection and ornament, but are too prone to regard the care and management of timber lands for the production of timber crops as a matter of little concern and very impracticable. (The subject of the regeneration of forests is treated in the chapter on Forest-planting and Treatment.)

PRAIRIE-PLANTING

Whatever the ulterior object of prairie-planting, the subject of protection to the buildings, their occupants, and the cattle in the field should always be first considered. The crops in our Central States are most liable to injury from the southwest wind of summer, which dries them out, and the northwest wind of winter, which blows the snow from the land, causing it to lose the snow water. It also causes a loss of evaporation, which goes on even in winter from the bare ground, and from exposed crops, causing them to winter-kill. The same winds are also

the most uncomfortable to the occupants of farm buildings, and are most likely to cause dust-storms, which should be especially guarded against.

Windbreak is a general name given to anything that gives protection from wind. On the prairies it is often applied to a single row of trees planted for protection.

Shelter-belt is a term more often used to signify several or a large number of rows of trees, but the term is often used interchangeably with windbreak.

Grove is a term that refers to comparatively large bodies of trees which may be planted for shelter, fuel, or other purposes.

Protection to Buildings may be furnished by a few rows or a grove of trees. It is generally best to locate the buildings in a grove, or grow one up around them, so that protection may be afforded from every quarter to the best advantage. The garden should also be included in the grove or shelter-belt about the buildings.

Distance of the Trees from the Buildings and Roadways. Of whatever the protection consists, it should not be close to the buildings or to any paths which are used in winter, for the snow-drifts, which always form to the leeward of such protection, may become a great nuisance under such circumstances during winters of great snowfall. The windbreak had better be placed about one hundred feet back from the buildings, and if shade is wanted it can be obtained from scattered trees near the buildings, which will not drift the snow. The same rule applies to the planting of trees on the north side of a roadway. The drifts of snow which would be formed to the leeward of a windbreak so planted would take longer to thaw in the spring, and would keep the road muddy and in poor condition after those that were not protected had become dry and firm. A row of trees is very appropriate by the side of a street or roadway and affords a pleasant shade, and if not planted

too closely together will not drift the snow sufficiently to be an objection.

Protection to Crops by Windbreaks. The objection to windbreaks close to driveways may also be made against their use in fields, for they often keep the land for a short distance to leeward wet and in unfit condition to work after the rest of the field has become dry. This is an objection where spring grains are grown, but to winter grains it is an advantage. On the other hand, the protection of a windbreak may give a much-needed or beneficial covering of snow to crops on the leeward side. The protection from dust-storms and drying winds has already been mentioned. The important question is how to get the advantages without the disadvantages. In many sections the disadvantage of having the snow linger on the field near the windbreak may be overcome by leaving a strip of land near it in permanent meadow, or use it for a rotation that does not take in crops that require very early planting. But even with spring-planted grains, it is more than probable that windbreaks properly planted are an advantage when their benefits are considered for a series of years. It ofttimes happens that low windbreaks are more beneficial than high windbreaks in holding the snow on the land, for the high windbreaks often form a great drift that may remain late in the spring, while the low windbreak nowhere forms a large drift, but spreads the snow for long distances. Professor Budd says that in parts of the great continental plain of Russia, where the climatic changes are much the same as in this section, the use of low windbreaks in wheat-fields is very common.

Height of Windbreak. From the preceding paragraph it will be seen that low windbreaks may often serve a better purpose than high ones in protecting fields. Exactly what is meant by a low windbreak may be an open question, but for the purposes of this discussion a low windbreak may be

considered one under twenty feet in height. In Russia and at the Experiment Station at Indian Head, Manitoba, windbreaks of *Artemisia tobolksiana*, which seldom grows more than eight feet high, are often used. About farm buildings windbreaks cannot be too high, and for this purpose the largest, longest-lived trees should be used.

Kinds of Trees for a Windbreak. In too many instances too many tree-planters on the prairies have put out exclu-

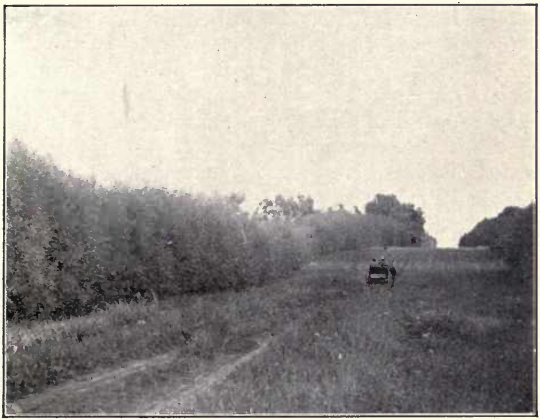

Fig. 3.—A young White Willow windbreak on dry prairie. Grown entirely by mulching after being well started.

sively quick-growing, short-lived trees, such as the Cottonwood and Lombardy Poplar, and after fifteen or twenty years they have found their trees dying and nothing coming on to take their places. The quick-growing kinds are very desirable as a protection for the near future, but they are often short-lived and should never be planted alone. Among them should be planted a sufficient number of

long-lived and perhaps slower-growing kinds, to afford protection in later years, when the short-lived kinds have died out. The soil and location have much to do in determining the longevity of varieties; for instance, the Cottonwood and Lombardy Poplar are generally short-lived trees when planted on dry land, but when planted in locations where their roots reach the permanent water-level, their period of life may be considerably lengthened, and they may then even be regarded as long-lived trees.

In starting a grove or windbreak on our Northern prairies, there is probably no better tree to begin with than the White Willow. It is quick-growing, rather long-lived in most situations, makes good summer fuel, and renews itself very rapidly from the stump. The Green Ash would probably rank next as a pioneer tree. The White Elm, and the Catalpa where it is hardy, are also very valuable for this purpose, but, generally, should follow the White Willow. The Cottonwood may sometimes, though very seldom, be the best to use, but on average prairie land it would be better if the White Willow or Green Ash were always planted instead.

After a good windbreak has been secured, it is safe to plant out the hardy coniferous evergreens and such trees as the Mountain Ash, European White Birch, and other similar ornamental trees. Wind protection is beneficial to all trees on our prairies and necessary for many of our best ornamental kinds and often makes the difference between success and failure in growing them.

Distance Apart. In the planting of groves, we should aim to get the land shaded by the trees as soon as practicable, and to keep it covered with a canopy of leaves. The United States government recommended the planting of trees four feet apart each way, with the idea that when so planted they would quickly shade the ground and consequently keep out grass and retard evaporation. Some

successful plantings have been made on this plan, but when planted so closely together, the branches grow into the rows after a few years and cultivation must be discontinued. In this country we have so much very bright sunshiny weather that grass can grow under foliage that would kill it out in a more humid climate, and we find that trees planted four feet apart each way seldom afford sufficient shade to kill the grass under them for many years. This is especially true of such trees as the Cottonwood, Lombardy Poplar, and White Elm when planted alone, as they have open foliage that does not furnish a dense shade. Among tree-planters who have had a large experience in prairie-planting, there has been a tendency of late years to plant two feet apart in rows eight feet apart, and some of our most successful planters prefer even more room than this between the rows. When plantings are made 2×8 feet, the same number of trees are required for an acre as when planted 4×4 feet, but the former distance has the advantage over the latter in that the space between the rows can be cultivated for perhaps ten years or more, by which time most trees will have formed a dense shade and be able to take care of themselves. Where a much greater distance than eight feet is allowed between the rows, we generally fail to get forest conditions for many years, and to that extent fall short of an important requisite in prairie-planting. The distances given here might need to be modified to suit different varieties and local climatic conditions.

Clear Plantings. Most of the plantings on our prairies consist wholly of one kind. In some cases best results are thus obtained, but they are seldom as satisfactory as plantings made up of several different kinds. One of the greatest drawbacks to plantings made up entirely of one kind is that the fact that drought, insects, or fungous disease may destroy the whole planting at one time, while in a judiciously mixed planting this could hardly occur.

Mixed Plantings, when properly made, have the following advantages: (1) They make possible the growing of species that form a protection in the least possible time, and still have, coming on in the same grove, longer-lived and better kinds to take their places. (2) Many kinds that are somewhat tender are helped very much by being grown among the hardier kinds until well established. In this case the protecting trees are called nurse trees. The Scotch Pine is seldom a success when standing alone on our Western prairies, but when partially protected by some

FIG. 4.—A good tree claim in Minnesota near the Dakota line. Located on high prairie. Soil very dry.

deciduous tree it stands very well. The same is generally true of Hard Maple, Catalpa, and Black Walnut toward their northernmost limits. (3) In good mixed plantings the ground is more likely to be properly shaded and protected from winds than it would be in clear plantings of such open-foliage species as the Cottonwood or White Elm,

which do well and afford good shade when mixed with Green Ash or Box-elder. (4) Mixed plantings are most interesting and ornamental. (5) They attract more birds by their better protection and the greater variety of food offered. (6) While the chance of injury to some of the species by climatic changes, diseases, and insects is increased, the possibility of total loss from any or all of these causes is reduced to the minimum.

The Most Important Constituent of a Prairie Grove of mixed trees should be some well-known durable kinds, as the Elm, Ash, Hackberry, Basswood, Soft Maple, Hard Maple, or Box-elder of deciduous kinds and such standard evergreens as White Spruce, Norway Spruce, Red Cedar, Bull Pine, and Scotch Pine, of which there should be a sufficient number to completely shade the ground when the others are gone. On the outside, especially on the north and west, it is often a good plan to put at least a few rows of White Willow, or possibly Cottonwood, to furnish a quick protection. The rest of the grove should consist of hardy sorts, and may include some of the evergreens and such fruit-bearing trees or shrubs as the Wild Plum, Wild Black Cherry, Russian Mulberry, and June-berry. These latter furnish food for the birds and may often be a help in supplying the home table. The plan of planting with a view of providing some food for birds is not mere sentiment, for they protect our gardens from many insects, and if we furnish an abundance of Russian Mulberry they will not trespass much on our strawberries or raspberries. It is the author's opinion that in all our prairie-planting we should pay more attention to using our native fruits and Russian Mulberry as plants of secondary importance.

List of Trees for Planting. The adaptability of trees to any locality is not alone dependent on climate, but is affected very largely by the quality of the soil, so that any list of trees that might be given for a large area would

necessarily be open to some criticism. Lists of this sort should be regarded as suggestive only, and the intelligent planter will naturally obtain in addition the experience of tree-planters in his locality before deciding on the kinds to plant. Herewith are given lists of trees for the northern prairie States, as there is commonly a lack of such information among the people of that section.

For Porous Moist Soils in Southern Minnesota and Northern Iowa. White Elm, Black Walnut, Green Ash, and Hard Maple in equal quantities, with a scattering of the fruit plants. The Hackberry may wholly or in part take the place of the White Elm, and the Box-elder the place of the Green Ash. The White Willow, Basswood, and Soft Maple would also do well in such a location. One of the main kinds might be replaced by the White or Norway Spruce, Douglas Fir, or White Pine. In fact such land as this will grow any of the trees adapted to this section.

For Dry Prairie Soils in Southern Minnesota and Northern Iowa. Green Ash, Box-elder, White Elm, and White Willow in equal quantities, with a scattering of fruit plants. Basswood and Hackberry might be used to a limited extent, and White Spruce, Red Cedar, Norway Pine, White Pine, or Scotch Pine might be used in the place of one of the main kinds.

For Moist, Porous Prairie Soils in Northern Minnesota and the Dakotas. White Willow, White Elm, Box-elder, Basswood, and Green Ash in equal quantities, with a scattering of fruit plants. In some localities it might be best to use Cottonwood on the outside of the grove. The Hackberry might take the place of part of the White Elm and White Spruce, Arborvitæ, Norway Pine, Bull Pine, Red Cedar, and some other conifers might be used to a limited extent.

For High Prairie Soils in the Dakotas. Cottonwood, White Willow, Box-elder, and White Elm in equal quan-

tities, with a scattering of fruit plants. White Spruce and native Red Cedar might also be used in a small way.

Fig. 5.—Hardy Catalpa. Plantation of South Amona Colony, Kansas.

Lists of Trees Commonly Planted, arranged in the order of their hardiness: Deciduous trees—Green Ash, White

Willow, White Elm, Box-elder, Basswood, White Poplar, Hackberry, Soft Maple, Canoe Birch, Yellow Locust, Catalpa. Evergreen trees—Red Cedar, Dwarf Mountain Pine, Jack Pine, Bull Pine, White Spruce, Austrian Pine, Scotch Pine, Douglas Spruce, Norway Pine, Norway Spruce, and White Pine.

Size of Trees. In the case of deciduous trees it is generally best to start with one-year-old thrifty seedlings, although trees two years old may often be used to advantage. The Oak, Walnut, and similar trees are better started from seeds where they are to remain, and the White Willow should be started from cuttings. Seedling Elm, Ash, and Cottonwood may often be pulled from some river bank or lake shore, or bought of nurserymen at a very low figure, or they may be raised from seeds. White Willow cuttings can generally be obtained from some neighbor or from nurseries. In the case of conifers, transplanted seedlings should be used where they are to be planted amongst grass or brush; but where best conditions are found, two-year, or even one-year, seedlings may be successfully set out. Whatever the source of any stock that is to be planted, it should be thrifty and vigorous and not weak or diseased.

Methods of Planting. The methods used in prairie-planting are much the same as for transplanting in the nursery. In every case much pains should be taken to have the soil in the best condition. It is generally better to delay planting for a year than to attempt it in poorly prepared soil. Tree plantings have been made on our prairies by sowing tree seeds broadcast in autumn after first carefully preparing the soil, but the plan is seldom successful. A start can, however, be made from seeds by planting the seeds in hills either alone or with corn or beans. In the latter case the tree seedlings often do very well and do not interfere with the growth of the crop. The seedlings are cultivated in the spring after the crop is re-

moved, and as they are in rows, this is a very simple matter. The common and generally most successful plan with trees that can be easily transplanted is to start with seedlings and plant in rows. The simplest and easiest way of doing this is to furrow one way, mark out the other way, and plant the trees in the furrows at the intersections. If Black Walnut or any of the oaks are wanted in a mixed planting it is generally best to plant the other species first and put in the nuts or acorns afterwards. Where it is desirable to plant seedlings or cuttings to fill vacancies, a pointed stick or spade may be used to make the hole. Whatever method is used in planting, it is most important that the soil be packed firmly around the roots, so they will not dry out. If the soil is dry, it cannot be made too solid around the roots. If cuttings are used, they should be made about 14 inches long, and in planting be pushed into the loose soil in a slanting position, leaving only one bud above the surface, as recommended for the planting of cuttings.

Cultivation should be commenced shortly after planting and be repeated often enough to keep the top three inches of soil loose, so as to form a dust blanket to retard evaporation during dry weather. The soil should never be allowed to become baked hard after a rain, but the crust should be broken up with a horse cultivator as soon after a rain as it can be worked. Cultivation should be discontinued after the first of August, in order to encourage early ripening of the wood. The weeds that grow after this time of year will do no harm.

One of the best tools for early cultivation of small seedlings is Breed's Weeder, which may be worked both ways and cleans out the weeds to perfection. The ordinary corn cultivator is also a good implement for this purpose. Later cultivation should consist of working the soil with a one-horse cultivator or plough. If the horse implements are properly used there will be no necessity of hand hoeing, for the few weeds that grow in the rows of trees will do no

injury to them. Some planters sow oats among the young trees for protection when cultivation ceases, but if field mice are abundant it may be best not to do so. Late in autumn of the first year or two after planting some soil should be turned towards the trees with a plough to protect them.

Thinning. In growing prairie groves, we should always aim to have the tops of the trees just touch one another without serious crowding, but still have the soil shaded and protected from wind. In order to bring this about, the grove must be thinned occasionally, for although the trees would thin themselves if left alone, it would be at the expense of growth and perhaps cause serious injury. Trees that are crowded together may suffer more from drought than those that have plenty of room for their roots. This is especially true of tender trees on dry land. If the trees begin to crowd one another, the poorest should be removed, but this should be done carefully and never to such an extent as to let in much sunlight, which would encourage the growth of grass, weeds, and side branches. Thinning may be done at any time, but if the wood taken out is to be used for fence-posts or poles, it would be better to cut in winter and peel at once to aid it in curing.

The Blowing Out of Small Seedlings planted in prairie soil is not uncommon where they are in very exposed situations. The movement of the young seedlings by the wind keeps the soil loose around them, which the severe winds blow away. Occasionally by such means the roots may be left three or four inches out of the ground the first season. In such very severe locations it is often a good plan to mulch the soil with straw or similar material until the seedlings are well established, after which they may be cultivated, or the mulching process may be continued until they will take care of themselves.

The Proper Location of the Buildings on a Farm is a very important matter and seldom receives the attention

which its importance demands. The position of the buildings determines the location of the drives and of the shelter-belts if any are to be planted. There are many factors which should enter into the study of this question, among the first of which is the lay of the land. Good drainage and good water are the first requisites for the location of a home, after which come convenience and beauty. It is very desirable that the first location be made just right, since when other improvements and buildings have been commenced it can seldom be changed without much extra expense. In the case of most of our farms the subject of plans is conspicuous by its absence, as small cramped grounds about inconveniently arranged buildings bear abundant evidence.

In Fig. 6 is shown four plans suggestive of the proper location of the shelter-belts about farm buildings located on level prairies, and varying according to the location of the main highway. Five acres in the form of a rectangle, 25 rods wide and 32 rods long, are included in the land about the buildings, and this has a shelter-belt five rods wide on the north and west sides, and on the south side two rows of trees ten feet apart, with the trees one rod apart in the rows. Within this enclosure are all the farm buildings, orchard, fruit, and vegetable garden, barnyards, etc. The house should be within 100 feet of the road, and the stock buildings at least 100 feet from the house and garden. About the buildings and garden some supplementary windbreaks and ornamental trees and shrubs will be needed for wind protection and for beautifying the place. This arrangement gives plenty of room for the buildings, barnyards, garden, and orchard, and, while all the land enclosed may not be needed for these purposes, the remainder is well adapted to the growing of general farm crops. The plans are only suggestive and no attempt is made to work out details, and there are comparatively few farms that they

would fit exactly. For instance, while it is desirable to have the buildings centrally located, their position must frequently be pushed to one side on account of a swamp or

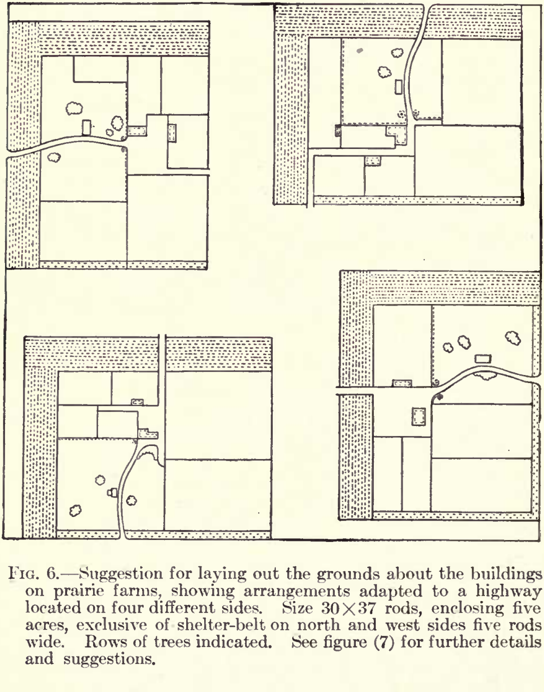

FIG. 6.—Suggestion for laying out the grounds about the buildings on prairie farms, showing arrangements adapted to a highway located on four different sides. Size 30×37 rods, enclosing five acres, exclusive of shelter-belt on north and west sides five rods wide. Rows of trees indicated. See figure (7) for further details and suggestions.

lowland which is not suitable for them, or their position may be determined by a beautiful natural grove. Fig. 7 shows a plan for a south front drawn on a larger scale. It

may often be desirable to change the shape of the land enclosed, but in the great majority of prairie farms a plan similar to this would work out to good advantage and the area enclosed by windbreaks could often be increased to ten acres to good advantage.

A rule that should be carefully followed in all tree plantings is that the view from the most commonly used rooms

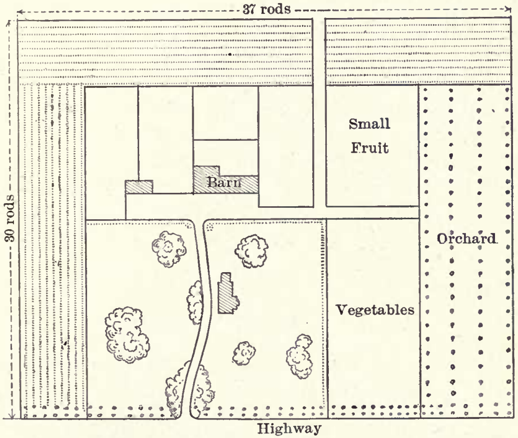

Fig. 7.—Suggestion in detail for laying out the grounds about the buildings on a prairie farm. Highway on south, size 30×37 rods, enclosing five acres; windbreak on north and west five rods wide. Two rows of trees next to highway. Rows of trees indicated.

of anything that is suggestive of pleasant associations or that is especially interesting or entertaining should not be cut off. Under this head would be included the view from the living-room windows, of the travelled wagon-road or perhaps of the railroad, of the neighboring houses or perhaps a near-by lake, and of the important fields on the farm,

especially those where stock is pastured. These views can generally be secured without seriously impairing the value of the windbreaks, by cutting small openings in them or perhaps by simply shortening the trees, so that they will not interfere with the line of sight.

The Cash Value of properly placed (not misplaced) shelter-belts is difficult to estimate, but they have an actual cash value aside from their ornamental value. From a number of observations I am inclined to believe that such a shelter-belt as is here described will often add as much as $1,000 to the selling price of a quarter section of land, and that two dollars per annum for each head of neat cattle kept is not a high estimate of its annual return. Besides this, if seedlings of the native wild plum is used as a nurse crop in the shelter-belts it will often return good crops of fruit for perhaps ten years, which, while inferior to our cultivated kinds, is exceedingly valuable for culinary purposes and appreciated by every farm household.

CHAPTER V.

FOREST REGENERATION AND TREATMENT.

THE timber lands of this country should, as a rule, be managed so as to get the greatest cash returns from them, for that only is practical forestry which has this fundamental feature always in view. Our virgin forests have contained, and those remaining now contain, a large percentage of trees past their prime and losing in value each year they stand. Such forest products should be worked up as soon as a good market is found for them. In virgin forests there is no increase, the annual growth being just balanced by the annual decay under normal conditions.

The Cultivation of Trees on timber lands in this section has never received much attention, and the only data as to the rate of increase that we have to follow are what can be obtained from the native forests, and these are for this reason only approximately correct. In European countries and elsewhere it has been proved by long experience that more timber is grown per acre, and that the growth is much more rapid, on land where some attention is given to systematic forestry than on that which is left to itself, and it will seem reasonable to believe this when we consider that much of the energy of trees may be expended in fierce competition with neighbors, which may weaken them all and perhaps bring about unhealthy conditions, and that natural forest land is generally unevenly stocked with trees, many of which are rotten or otherwise defective, and often with those that are not the most profitable kinds to grow. In

the cultivated forests, unnecessary crowding is prevented by judicious thinning, and the land is kept evenly and completely stocked with the most profitable kinds.

Succession of Tree-Growth is an expression sometimes used as though there were a natural rotation of trees on the land. There is nothing of the sort. Sometimes hard woods will follow pine, or the pine the hard woods, where the two were mixed at the time of cutting and there was a young growth of one or the other kind which had a chance to grow when its competitor was removed. Where land is severely burned after being cut over, the trees that show first are generally the kinds with seeds that float long distances in the wind, such as Poplar and Birch, or those having fruits especially liked by birds, such as the Bird Cherry, which is very widely distributed. These show first on account of getting started first. The Pine and the other trees may come in later owing to their being seeded later, or owing to the later advent of conditions favorable to their germination and growth. It may happen in the case of burnt-over pine land that pine seed is distributed over it the first year after it is burned, but owing to there being no protection from the sun the young seedlings of White and Norway Pine, which are very delicate, are destroyed. After a young growth of Poplars has appeared the pine seed may find just the right conditions for growth for a few years and finally get ahead of the Poplars and crowd them out, while in the meantime it is being much improved by the presence of the Poplars, which grow rapidly and force the Pines to make a tall growth. On the other hand, however, the Poplars, Birches, and other trees and shrubs and even weeds may sometimes make so strong a growth as to kill out the young Pine seedlings if they are not sufficiently well established at the time the mature growth is cut.

Regeneration is a term commonly used in forestry to

[*To face page* 62.]

FIG. 8.—Virgin Forest. White and Red Pine mixed. Near Mille Lacs, Minnesota. Good Natural Regeneration.

signify the renewal of forest trees upon the land. It is a convenient term and well worthy of general introduction into the forest literature of this country. The different forms of regeneration may be referred to as (1) regeneration by natural seeding; (2) regeneration by artificial seeding; (3) regeneration by sprouts and suckers (*i.e.* coppice); (4) regeneration by planting seedlings; (5) regeneration by planting cuttings. The method of regeneration best adapted for one section may not be at all fitted for another under different conditions, and often it is best to combine two or more of the different forms of regeneration.

Regeneration by Seed. Where natural regeneration by seed can be easily brought about, it is generally the best practice. This is especially true in sections where timber is comparatively cheap, as is generally the case in this country. It may be greatly assisted by stirring the surface of the soil in good seed years and in other ways bringing about conditions conducive to the germination and growth of the seeds. Where it is practicable to use it, a disk harrow is an admirable implement for breaking up the soil so as to allow the germination of seeds. Where a disk harrow cannot be used to advantage, and it can seldom be so used on new land in this country, it is a good plan to use a drag made by tying together several oak branches or small logs. Good seed years do not occur very often in our most desirable species, and it is very important to take advantage of these good years when they do come. At such times it is often a good practice to make extra cuttings in order to let in light and air, as well as to stir the soil and so make it possible to secure a good catch of the seed.

The methods adopted to secure natural regeneration by seed may be divided into three systems, each of which may be best adapted to some special conditions. These

are known (1) as the Selection Method, (2) as the Strip Method, and (3) as the Group Method.

The Selection Method refers to the cutting of the mature trees and to the removal of inferior trees to make room for the better kinds. In this system much care should be exercised to prevent the growth of grass, which generally comes in when the cutting is done more rapidly than the seeding trees can seed the bare land. On the other hand, it is just as important to exercise care that the young seedlings which have started have sufficient light so that they can make a good growth and not be shaded out by the older trees. The removal of a single tree often lets in so very little light that seedlings cannot get a good start. On this account the group method is probably best adapted for general use.

Fig. 9.—Trees with branches cut off before falling, so as to prevent injury to young growth around them.

Strip Method is a term that is applied to the system where the trees are removed in narrow strips, across which the remaining older trees can easily scatter their seed The best width of strips will depend on the species and the local conditions. Some who advocate this method claim that the strips should not be wider than the height of the trees, while others would allow strips three or four times the height in the case of the Elm, Maples, and Pine, and in the case of Birch even eight times may not be too much. Such strips should generally begin on the side opposite from the prevailing winds at seeding time, so the seed will be blown onto the denuded land. In the case of hillsides the strips should begin on the lower slopes, and the work be continued towards the summit so as to assist the distribution of seed.

The Group Method is a system of cutting strips successively on the inside of certain groups. This may be termed a natural method, and for general use, especially in mixed woods and where the land and conditions are quite variable, it is much the best. It gives a chance to adapt the method of cutting to the different species and to the different conditions which may be found in the forest. For instance, a tamarack swamp, dry knoll covered with oak, a steep hillside, and level, rich, rocky land, each covered with the trees peculiar to it, would very likely all be included in almost any forest tract of any considerable size in the Northern States, and each portion should receive special treatment. We can begin with one group or several, and we can start our regeneration in each group perhaps where there is already a good growth of young trees. In fact this system gives us a chance to begin regeneration where the greatest necessity or the best chance for it already exists.

The size of the openings will depend here as in the strip method on the species grown and natural conditions. Generally the first openings will be from one-fourth to one-half acre or more, and the strips taken

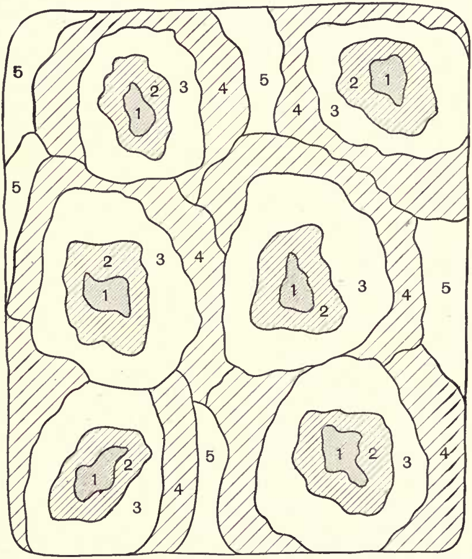

FIG. 10.—Diagram illustrating the system followed in the group method of cutting. Cuttings are begun at points marked 1, and are gradually extended by successive cuttings as indicated by Figs. 2, 3, 4, and 5. After Schlich.

around them should in width not greatly exceed the height of the trees in the strips next to be cut. Successive strips should be cut only when the previous strips had become well stocked with trees, *i.e.* when regeneration is accomplished.

Of course the regeneration in any case should be managed with the same care that should be given to any well-managed forest to bring about the predominance of the most valuable kinds under the best light and soil conditions.

Regeneration by Artificial Seeding. Occasionally it may be desirable to sow seed in woodlands. This is especially so in the case of some of our nut-trees such as Black Walnut, Butternut, and Oaks, which readily renew

FIG. 11.—Tree seeds sown in patches in old woodland.

themselves by such means. In the case of Pine and Spruce, however, success is quite uncertain under such treatment. Perhaps it is most certain with Pine and Spruce where it is practicable to furrow out with the plough, as for instance it might be on some of the sandy lands of Wisconsin and Michigan where furrows might be run between the trees or the land loosened in patches with a hoe. In this case the standing trees afford the proper shade conditions for the seedlings. In the case

of clear fields it is quite a simple matter to sow the seed in furrows.

Sowing in Patches. It is quite common in some of the European forests to see patches of land, perhaps four feet square, at twenty-foot intervals, which have been stripped of their mossy cover and sown to seed. These afford a sort of nursery throughout the forest, from which seedlings may be transplanted and on which a

FIG. 12.—Good natural regeneration of Spruce in Manitoba.

number of seedling plants are left and form a good forest cover.

Sowing in Clear Fields. Pine and other seeds are sometimes sown in clear fields with oats, when the straw protects from the sun in summer and the stubble holds the snow and acts as winter protection. Seed of Ash, Maple, Elm, and some other trees may sometimes be sown in the hills with corn to advantage in prairie-planting,

and Willow cuttings may also be used in the same way or with beans.

Natural Reseeding of the land is almost the only practical means of restocking cheap forest land, as other methods are too expensive. It generally takes place readily, and the only reason why it is not more successful is the frequent destruction of the young seedlings by fires and cattle. The small crooked branching Pine and other

Fig. 13.—A fine young growth of Norway Spruce (*Picea excelsa*) in the forest garden of the "Giessen Forestry School" in Hessen, Germany. A good illustration of the results of regeneration by planting seedlings.

seeding trees that are always left by lumbermen in their operations here, and generally considered worthless, perform a very important work in producing seed, and it is a pity that there are not more such trees left to produce seed for our cut-over lands. When such trees escape

the first burning after the land is cut over, they often remain for twenty years doing their blessed work of distributing seed each year, and when the conditions exist for germination and growth, the seed grows and lives. Sometimes where such trees are not left by lumbermen, or where they have been destroyed by fire, it has taken twenty years to get the land properly reseeded to White Pine by the slow process of seeding from trees at a distance of half a mile or more.

The Covering of Tree Seeds in Woodland, whether the seeds are sown naturally or artificially, can often be best accomplished by stirring up the soil with a strong harrow or a brush drag made of the branches of an Oak or other tree having strong wood. This may sometimes be done most advantageously before the seeds fall, and at other times after they have fallen. Where the soil is made loose and the forest floor is broken up before the seeds fall, they are generally sufficiently covered by wind and rain. They may sometimes be covered most satisfactorily by driving a flock of sheep over the land after the seed has fallen, the feet of the sheep pressing the seed into the ground.

Regeneration by Planting Seedlings. This form of regeneration is practised to a considerable extent in sections where timber is high in price. It is often the most economical way of securing a stock of coniferous trees upon the land. Under the conditions which frequently prevail on our cut-over land, there is very little chance for natural or artificial regeneration of desirable kinds by seed, owing to the fact that all the seed-producing trees were cut when the land was logged, or have since been destroyed by fire and the ground covered by a growth of weeds and inferior trees; but seedling Pines can often be set out at intervals of perhaps ten feet apart each way where they would be sufficiently crowded by

[*To face page* 70.]

FIG. 14.—Wood road and firebreak, Giessen, Germany, in Norway Spruce Forest.

the weeds, Poplar, and other fast-growing trees, so that they would take on an upright form quite free from side branches until their tops interlaced, after which they would crowd one another. Such planting can often be done at an expense of about two dollars per acre in addition to the cost of the seedlings, if the work is done

Fig. 15.—Old Pine cuttings after being once burned over.

with a mattock. Under favorable conditions, the work can be done for half this figure. It is not too much to expect that a man and boy can plant 1,000 seedlings in a day of ten hours under reasonably favorable conditions. It is necessary for the success of such work that weeds be prevented from smothering the trees, which they

are liable to do if left without care for the first few years. Until the seedlings get well started, and to prevent this, it may be necessary to cut back the crowding plants every summer for a few years.

Old Fields that for any reason it may not be desirable to plough entirely can be successfully planted by furrowing out in autumn where it is desirable to plant, and in spring

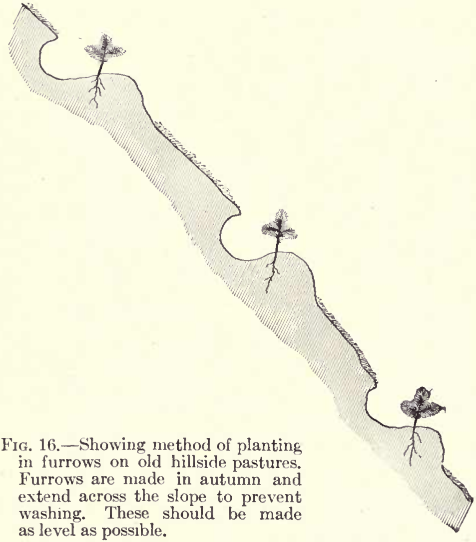

FIG. 16.—Showing method of planting in furrows on old hillside pastures. Furrows are made in autumn and extend across the slope to prevent washing. These should be made as level as possible.

planting on the edge of the furrow where the soil has fallen from the furrow slice. In the case of hillsides of this kind that are liable to wash, the furrows should run across the slope and be made nearly level and will thus hold water and prevent drying out. (Fig. 16.)

Mound-Planting is a term which signifies the planting of trees on mounds or on the surface of the land. This is sometimes done on wet lands for the purpose of getting the roots above standing water, and it is a practice which can be followed in the case of several trees that do well upon rather moist soil, although they may die if put at once into standing water when young.

Regeneration by Cuttings. There are few trees that can be grown in general practice from cuttings, but it is the best way to start Willows, since seedlings of them are generally quite difficult to obtain. Some species of the Poplar can also be grown to best advantage in this way.

Regeneration by Sprouts and Suckers. Some trees, such as the Willow, Poplars, Oaks, Chestnuts, and Maples renew themselves very readily by sprouts and suckers. Land that is managed on this plan for regeneration is termed COPPICE. With the exception of the Willow and possibly one or two other trees, the growth from coppice is not so large as that from seedlings, and it is seldom employed for other purposes than the production of firewood. In order to get the best growth in this way, the trees should be cut close to the ground when they are dormant, and the stumps left highest in the centre, so they will tend to shed water and not rot. The advantage of cutting close to the ground is that the sprouts that come out from the trunk soon get roots of their own, which makes them more durable than when they depend entirely upon the old stump roots, and they are much less liable to be broken off in high winds.

Pollarding consists in cutting back the side branches of a tree or cutting off the main stem at a few feet from the ground. The branches may be cut off close to the main stem or at a short distance from it, the latter method being preferable. New shoots spring from

the cuts, and these are again cut when of suitable size. What has been said in regard to the season and manner of cutting in the previous paragraphs is practically true here. This process is mostly used in the case of Willows and Poplars to obtain material for basket-work, small poles, fuel, etc.

Time of Rotation is a term used to indicate the age to which trees are grown. The length of this time will depend on the species and on the conditions. For some

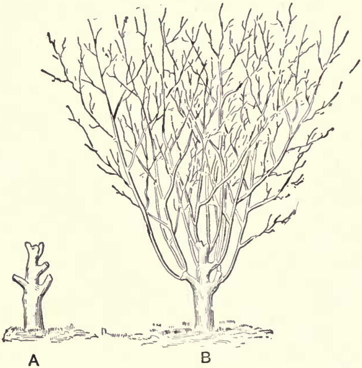

Fig. 17.—Showing proper way of cutting Pollards and growth after same has been cut.

species not less than eighty years should be allowed for full maturity, while still others may be successfully worked on a thirty-year rotation period. It is not used in the same sense as in ordinary agricultural operations, where it signifies frequent changes of the crop for several years with a view to getting the most out of the soil. Since trees do not impoverish the soil, but improve it, there is no

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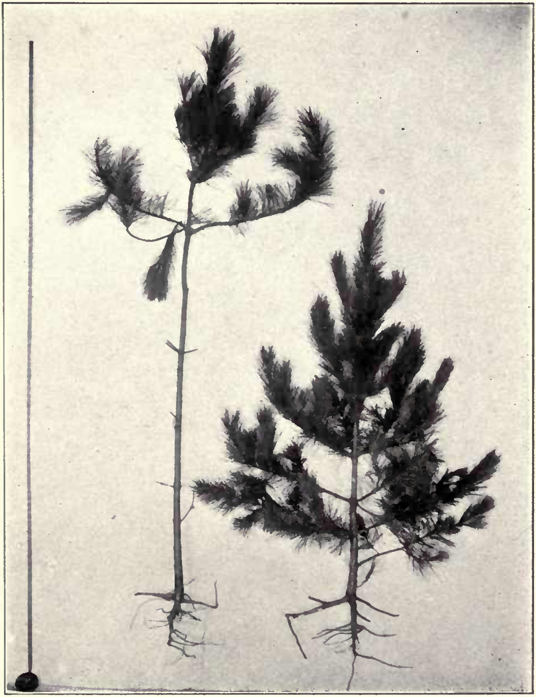

FIG. 18.—Crowded and open grown Norway Pine. Crowded trees form the most good timber in the shortest time. Open grown trees have many side branches, and consequently form poor timber.

necessity for any such method of rotation in forestry as there is in agriculture.

Pruning of Forest Trees is generally an expensive operation and little is required if trees are properly crowded when young, so that they take on an upright form free from side branches. If they are not crowded when young, many side branches are formed, which generally die out when the trees get large enough to shade all the ground. In some cases these dead branches drop quickly to the ground, and in others they remain for years, producing knots and irregularities in the wood formed in the meantime and should be removed. Trees grown in the open retain their lower branches more or less throughout life, and they produce in consequence timber of inferior value as compared with trees grown in properly crowded woods.

Large wounds made by cutting off green branches should be painted with some protective covering such as white lead. It is often desirable to remove dead branches, and it is the practice to do so in some of the plantings of White Pine that have been made in New England. It is said that the lumber there is so greatly improved by so doing that the operation is a paying one. But under ideal conditions for the development of timber trees very little is gained by pruning.

The Young Growth is Often Injured in ordinary lumbering operations by the felling of the trees, which bend them to the ground and often break them. Where special care is desired to protect the young growth it may be desirable to lop off the branches before felling. This is practised to some extent where forests are very valuable.

The Small Dead Twigs on such trees as Spruce, and also the shrubbery which may surround them, are often a very **valuable protection** against sun-scald. This also protects from drying winds, which would otherwise perhaps sweep through the forests and do them injury.

Forest trees seldom do best where they are subject to a strong draft of wind around the trunks. While under some conditions it may be desirable to remove the dead branches from trees, yet even if it is decided to do this in the interior of the forest, it is generally best to leave the borders without such pruning in order to protect it from drafts.

Forest Weed is a term used to signify any growth that may occur in forests which crowds the other growth and so prevents it from developing to the best advantage. It may apply to raspberry bushes, hazel brush, poplars, and other similar materials which often come in our forests in the early growth of the plantation; or even to large inferior trees which are in the way of the proper development of the better species. But a tree may at one period of its growth be of much value in a forest in producing shade and acting as a nurse tree, while later on in its growth, after its usefulness has been completed, it may be regarded as a weed.

Thinning is the most important part of the forester's art in securing good timber and in reseeding the land. The ideal condition in the life of timber trees is to secure a natural crop of seedlings so crowded when young as to increase very rapidly in height and produce slender trunks free from side branches. When this crowding has gone far enough the less valuable and weaker trees should be removed to give the better trees sufficient room for their crowns to develop. These remaining trees in the course of a few years will again crowd one another too severely, and this process of removing poorer trees must then be repeated. Then when the final stand of trees is approaching maturity, thinning should be commenced to let in light and air to produce the conditions under which seedlings develop to best advantage.

Heavy thinning should be practised only after very

careful consideration. It is seldom desirable, as it lets in much sunlight and may encourage a growth of grass. Where natural regeneration is practised, only such openings should be made as will be shortly covered with valuable species.

Important Principles that Should be Remembered: (1) That increase of wood is proportional to leaf surface and therefore the lands should be kept as nearly as possible covered with a canopy of leaves, which should be on trees that are valuable for their timber. (2) That leaves need light; therefore partly shaded branches form but little and imperfect wood, and those that are very heavily shaded die out; crowding prevents the formation of branches on trees and is important in securing the best timber. The amount of waste branchwood varies greatly, it being very much in trees that are entirely open grown, and very little in trees that have been severely crowded. But as overcrowding causes decay, it is important to do the thinning as soon as the tree has taken on a proper form. Crowding on one side causes crooks, and these can be prevented by cutting off the crowding tree or branch.

Waste in Forests occurs, as has been partially stated, in branchwood, crooks, rot, and in growing of the kinds of trees that are not marketable. The kinds that are marketable depend largely on the demand. In considering this subject it is best to be conservative and to select kinds that are of stable value and not likely to go out of fashion. Since crowding is best done by small trees among the large timber trees, they should be of a kind that are marketable when small.

Much waste in timber is caused by cutting trees when small. The amount of waste in the shafts of straight trees, excluding trunks, branches, and bark, may vary from eighty-one per cent. in a tree eight inches in diam-

eter and ninety feet high to six per cent. in a tree forty inches in diameter on the stump and one hundred feet high. It will thus be seen that there is great loss from cutting trees when small, especially if they are growing rapidly.

Improvement Cuttings is a term used to signify an improvement of forests by cutting out inferior and crowding trees. This is a very important matter in getting almost any forest tract into a condition where it can be managed to best advantage under the group, strip, or other systems. Generally it will at first consist in removing the dead, rotten, and mature trees and those of inferior species, and so give better opportunity for the more valuable kinds. This is a matter that calls for much good judgment. Care should be exercised not to make openings so large but what they will shortly be occupied by seedlings of valuable trees. Where large openings are made they are apt to become covered with grass, which is a great detriment to any forest growth and always indicates that the cutting has been done too rapidly for best results.

The Axe and Saw, then, as will be seen from the foregoing paragraphs, furnish the most important means when used judiciously in securing the best growth of timber in forests of this country and the proper succession of growth on forest land.

The Farm Wood-lot is a customary feature on many farms in the Northeastern States. As a rule it occupies land that is of very little value for any other purpose. It is generally not managed at all, but left to look after itself, and often it is pastured. It is expected to furnish firewood, posts, and poles and an occasional stick of dimension stuff. Too often the best is cut and the poorest left to grow. Under such rough treatment the wood-lot becomes stocked with an inferior growth that is of little value except for firewood, and it does not produce as much

of that as it might under a different system of management.

Improving the Wood-lot. The general rules laid down for the management of forests will apply here. The cattle should be kept out, so as to give the young seedlings a chance to grow. Improvement cuttings should be introduced with a view of getting rid of the crooked and mature trees and those of inferior species, and of encouraging a growth of young seedlings of valuable kinds. Similar treatment should be given the sugar-orchard, in which the old heart rotten and weak trees should be gradually removed to make place for thrifty saplings as the latter need the room.

Osier Willows is a term that is applied to a variety of Willows which are grown for their twigs, which are used for basket-making. The plantations made for this purpose are termed osier holts. The growing of osiers has not been carried on to any great extent in this country, but they are generally imported. At Syracuse, N. Y., and near a few other large cities, it has reached a considerable degree of development. A large amount of these osiers are imported into this country each year, and an immense amount of willow basket material is used. The price paid for the rods, when of a proper length and in good condition, is about fifteen dollars a ton, green. The yield per acre around Syracuse, N. Y., is about four tons of green rods, but occasionally as high as eight tons has been obtained. Dried peeled rods are worth somewhere about sixty dollars per ton. In order to facilitate peeling, which in this case is termed stripping, the rods are steamed until the bark comes off easily. These are not as white, however, as those which are sap-peeled in the spring, but the latter are not as durable as steam-peeled rods.

The best soil for the growing of basket Willows is a

deep, sandy soil, drained yet moist. If water for irrigation can be commanded, so much the better, but the basket Willows will prosper on even rather dry soil of good quality, but do not grow as fast as on moist soil. Avoid locations where stagnant water stands in summer. Among the best situations is along the rivers and brooks that pass through a level country, and on small islands which frequently are found in the midst of streams, or

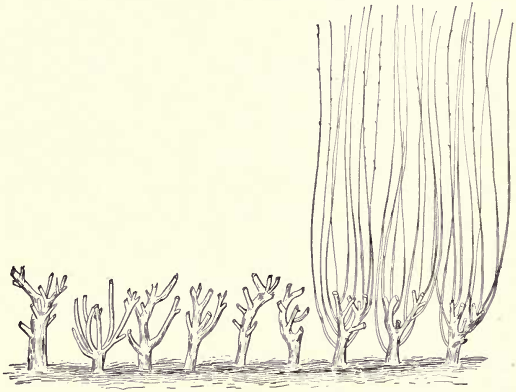

FIG. 19.—Showing Osier Willow Holt partly cut and part standing.

swales or hollows. If these places are occasionally quite wet in winter, it does not seem to injure seriously the basket Willows.

In preparing the soil for this purpose care should be taken to make it very rich, and if necessary for best growth, it should be heavily manured with stable manure and as carefully prepared as if for a crop of corn. The best

time for planting is in the late autumn, or very early in the spring, and the best cuttings are those about twelve inches long. Put these cuttings in so that their tops are even with the ground, but do not cover the tops with earth. Some growers prefer to set the cuttings about four inches apart in rows twenty inches apart for best results. This gives a thick, close growth, which sufficiently shades the soil between the rows that weeds cannot grow there. If the plants should prove to be too thick, every alternate one can be grubbed out after the third year. This method will require about 65,000 cuttings to the acre. Other growers prefer to set twelve inches apart in rows three feet apart. This gives a chance to work between the rows with a horse, which is quite an advantage under some conditions. This method requires about 15,000 cuttings per acre. (See figure 25.)

On land that is wet late in autumn the Willows are liable to grow too long, and not ripen their shoots, which is an important consideration in the growing of basket Willows, since if the shoots are not ripened at the time growth ceases, they are worthless for basket purposes, being soft and brittle. The rods should be cut the first year, even if of no value, for if the cutting is delayed until the second year, the plants will have branched, and will produce much less valuable material. The rods should be cut as near the surface of the ground as possible. They should then be tied in bundles about ten inches in diameter, and, if it is intended to sap-peal them, these bundles should be placed in running water, standing upright, until the leaves or sprouts appear in the spring, when they should be ready to peel. This method of peeling is termed sap-peeling. When it is intended to remove the bark by steaming or boiling, the bundles may be set up anywhere until dry, when they may be stored in racks or in covered sheds until wanted. Rods thus

treated will be of a darker color than those peeled in the spring after the sap has started, owing to the fact that the wood is stained by the coloring matter in the bark, which is dissolved and taken up by the wood. These dark-colored rods, however, make the most valuable baskets. Willows should never be cut when the sap is flowing, as the material is poor, being too soft and turning black when peeled. Besides, they injure the plants by robbing them of their yearly supply of root nourishment. The cutting should always be done carefully, and in such a manner as not to split or mutilate the stocks. The peeling is done by pulling the rods through a springy wooden fork, shaped like a clothes-pin, but larger, and with blunt edges inside. This presses against the rod and loosens the bark in strands without injuring the wood. The rod is afterwards dried in the open air and put up in bundles of fifty pounds for the market.

Peeled rods keep much better than those left with the bark on, and this is said to be the most profitable way in which to market the product. The Willow is generally a healthy plant, and rather free from insect enemies under ordinary conditions; but when grown in large groups of pure Willows, it is occasionally attacked by rust and also by insects. The leaf-eating insects are easily destroyed by Paris green, used in the same way as is common for the destruction of the potato-bug.

The Osier Willow, which has proven most productive of the long, slender shoots so desirable for basket-making, is the *Salix purpurea*, and at the Minnesota Experiment Station this has frequently made a growth of six feet long in a season. It should be understood by any one who undertakes this line of work that long, slender rods are desirable, and that one rod six feet long may be worth as much as several that are not over three or four feet long. Almost any Willow may be used for making the

common, coarse baskets, but for the better class of willow goods, the special Osier Willows should be grown. The common White Willow and also the Golden Willow produce rods of fairly good quality.

CHAPTER VI.

PROPAGATION.

Trees are Grown from Seeds or by Division. The latter term includes increase by cuttings, layers, buds, and grafts. Plants grown from seeds are generally more vigorous and longer-lived than those of the same species propagated in any other way. Trees should be grown from seeds when it is practicable to do so, but Willows and some other trees are apparent exceptions to this rule and seem to do as well when grown from cuttings as when grown from seeds. Varieties do not generally perpetuate their peculiar characteristics when grown from seeds, and must therefore be propagated by some method of division.

The Most Desirable Trees from Which to Propagate are those of good form and healthy growth; the latter is the one most important requisite, especially if new plants are to be grown by any method of division. It is not so essential in selecting seeds, as even weak plants may produce good seedlings, but unhealthy cuttings, layers, or grafts are of very uncertain growth. In general, it is best that the stock trees be healthy throughout, but a tree may have a rotten trunk due to some injury and still have perfectly healthy branches and be a desirable tree from which to propagate.

SEEDS.

Sources of Seeds. In growing trees from seeds, the source of the seeds is very important. It may be given

as a safe general rule that seeds are most desirable which come from trees grown in as severe a climate as that in which the seeds are to be sown. It has been found that trees of Box-elder and Red Cedar grown from seeds gathered in Missouri are not nearly as hardy in Minnesota as those from seeds grown in that State. It has also been found that seeds from the western slopes of the Rocky Mountains, where the climate is very humid, produce trees which are not so well adapted to withstanding the conditions of the Central States as trees grown from seeds from the eastern slopes, where the summers are very dry and hot and the winters very dry and cold. The climate of our Western prairie States is especially trying to trees, and it is necessary to exercise much more care in the selection of tree seeds there than it is in the more favored climate of the Eastern and Western coast States.

There are Conditions Under Which Every Species of Tree Thrives Best and makes its greatest growth, but the trees produced under these conditions are not always the hardiest. As they reach the limits of their growth, trees have a tendency, on account of drought or cold, to become smaller, more compact in form, and to fruit younger; *e.g.*, the Box-elder is a large tree in Kansas and Missouri, but as it gets towards the Manitoba line, we find it becomes dwarfed and more bushy in habit. Towards the southern limit of its range the tree becomes more open in habit and more liable to disease. The Scotch Pine seeds imported into this coutnry are generally saved from the small scrubby trees that are found in the higher altitudes of the mountains of Europe, because such trees produce the most seeds and they are most easily gathered from them, while seeds are seldom gathered from the large timber trees of this species, and it is very likely that this poor seed stock is responsible for much

of the scrubby appearance of many Scotch Pine plantations in this country.

Trees Have a Strong Tendency to Perpetuate Qualities which have been developed in them by climate and soil conditions. Hence, even though an essential point in considering the value of any tree is its hardiness, the question of size is important and should be taken into account, as we generally wish to grow trees of as large size as practicable. We may conclude, then, that since trees from a very mild climate generally lack in hardiness, and those from a very severe climate may lack in size, it is best to procure seeds from the best trees grown near by or from those grown under similar climatic conditions elsewhere. It is not generally necessary to limit this range very closely, as a hundred miles north or south of a given point will seldom make much difference in hardiness, unless the climatic conditions are very dissimilar.

The Place Where the Trees that we are to Set Out are Grown is not of so great importance as the source of the seeds from which they are grown; *e.g.*, seedlings of Red Cedar grown in Missouri from seeds of native Minnesota trees would be safer to plant at the extreme North than seedlings raised in Minnesota from the seeds of native Missouri trees.

Seedling Variations. In our common trees variations are not sufficiently marked but that we think of the trees as coming true from seeds, and yet careful observation will show to any one that each seedling plant is different from neighboring plants of the same species. Sometimes a seedling will occur that possesses especially pleasing or curious characteristics that are very marked and desirable. In such cases the seedling is generally propagated by some method of bud-division and makes a new variety. In this way have originated such highly esteemed kinds as Wier's Cut-leaf Maple, which was a

chance seedling of the Soft Maple, the Weeping American Elm, Cut-leaf Birch, Weeping Mountain Ash, Pyramidal Arborvitæ, and a host of other kinds that are propagated by bud-division by nurserymen. The person who is on the lookout for these or other variations will have no trouble in finding many that may perhaps be worth naming and propagating.

Gathering Seeds. All kinds of seeds should be gathered when ripe. In some cases it is best to pick them from the trees even before they are quite ripe, after which they will ripen if kept dry. Unripe seeds do not keep as well as perfectly ripe seeds. Most kinds of tree seeds are most cheaply gathered from the ground. In some cases this method can be greatly facilitated by cleaning up the land under the trees so that it will be smooth and even. Seeds of some species can often be swept up at little expense from under trees growing along the highway.

Germination of Seeds. There are many conditions which affect the germination of seeds:

(1) Seeds which are thoroughly ripened before they are gathered produce the best plants. Very immature seeds will very often grow, but the tendency with them is to produce weak plants. (2) Freshly gathered seeds, as a rule, are preferable to old seeds for sowing, and seeds that have never been allowed to become very dry are more likely to grow than those which have been severely dried. This is especially true of most of the kinds of seeds that ripen in early summer, the most of which lose their vitality very quickly when stored. (3) Some seeds, such as those of the Plum, Cherry, and Black Walnut, require severe freezing when moist in order to germinate. (4) Seeds that are covered with water will not generally grow. This is true at least of our Northern tree seeds. (5) The seeds of some trees germinate at a temperature near

freezing, while others require a much higher temperature. (6) After seeds of some plants have become very dry, scalding may aid them in germinating, while with others, scalding is injurious. It is sometimes desirable to soak seeds for one or two days in tepid water and then mix with sand and freeze before sowing. Lindley records that seeds found in raspberry jam grew after passing through the heat necessary to boil syrup (240 degrees Fahr.), and that seeds of Acacia grew after being boiled five minutes, but our common tree seeds will not stand such treatment.

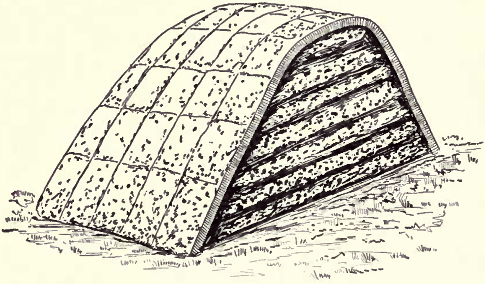

FIG. 20.—Cross-section of stratifying pit for storing seeds during winter, covered with inverted sods.

Stratification, as the term is used in this connection, refers to the storing of seeds mixed with layers of earth, leaves, or other material. It is customary to apply the term solely to seeds that are mixed in this way and kept frozen over winter. It is the common practice with the seeds of such trees as the Black Walnut, Hickory, Basswood, Plum, Cherry, and Mountain Ash. Where only small quantities are to be cared for they are generally mixed in boxes and the boxes buried in well-drained soil

out of doors, but where large quantities are to be handled, they may be mixed with soil on the surface of the ground and left until spring; such a pile is termed a pit. One of the best materials with which to cover seed-pits is inverted grass sod. It is often a good plan to have the material that is mixed with the seed so fine that it will easily go through a screen and leave the seeds separated for sowing.

Wintering Acorns and Other Nuts in Large Quantities. On account of the great liability to injure where

FIG. 21.—A Danish storehouse for nut seeds, where 5,000 bushels of acorns and beech-nuts are stored each winter. The nuts are put in 18 inches deep and turned every day.

a large amount of nuts are stored in heaps, and on account of the impracticability of stratifying them with sand, the following plan is resorted to in some sections:

A house is made, preferably with a sandy floor, so as to secure good drainage, and is covered with sod roof and sides, so as to keep out most of the frost. This may be of any size, but perhaps 20 feet in width and any length

would be very convenient. The nuts are spread over the ground about 18 inches thick, and are stirred frequently until frozen in winter. As soon as they thaw out they are turned once a day. In this way they are prevented from moulding, and from the other injuries that are so common to nuts stored in large quantities. It is desirable to keep the temperature from ever going much below freezing in such a storehouse.

Seeds May be Classified Into Three Groups: (1) Those that ripen in spring and early summer, (2) deciduous tree seeds that ripen in autumn, and (3) coniferous tree seeds.

Seeds that Ripen in Spring and Early Summer (Soft and Red Maple, Elms, Cottonwood, and Willows) should be gathered as soon as ripe, and, with the exception of the Red Elm, sown within a few days or weeks, as they retain their vitality but a short time. (Red Elm seed will not grow until the following spring.) In raising seedlings of this class, it is important to have land that will retain its moisture during the summer months or else that which can be conveniently irrigated, since these seeds must often be sown during very hot, dry weather, and as they cannot be covered deeply they are very liable to fail with any but the best conditions. The thousands of seedlings of Cottonwood, Elm, and Soft Maple that spring up on the sand bars along our rivers and lake shores show what are the best conditions for these seeds to germinate.

Cottonwood Seedlings can be grown by scattering the branches bearing unopened seed-pods along rows in moist soil and covering the seed lightly when it falls, but they are of so uncertain growth that most of our nurserymen depend upon the sand bars and lake shores for their supply.

Elm, Soft Maple, and Mulberry seeds generally grow well on any good moist soil. They should be sown

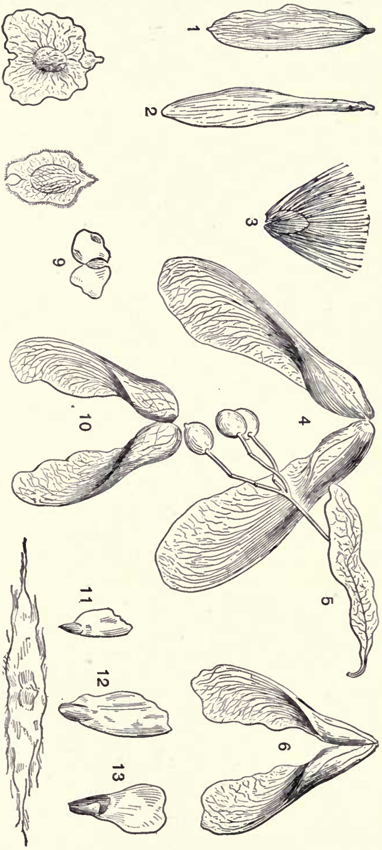

FIG. 22.—Some common winged seeds: (1) Black Ash; (2) White Ash; (3) Willow; (4) Soft Maple; (5) Basswood; (6) Box-elder; (7) Red Elm; (8) White Elm; (9) White Birch; (10) Sugar Maple; (11) Tamarack; (12) Pine; (13) Noble Fir; (14) Hardy Catalpa.

thickly in drills eight inches wide and three feet apart, or in narrow drills. Elm seeds should be covered with about one-half inch of soil, Mulberry with about one-fourth inch, and Soft Maple with about one inch. If the weather is dry the soil over the seeds should be well packed, and if the weather continues dry the rows should be watered. Watering, however, is seldom necessary on retentive soil if the soil has been properly packed. With proper conditions seeds so planted will start quickly and grow rapidly; the Elm will grow from six to eighteen inches and the Soft Maple twelve to twenty-four inches high before the first autumn. Such seedlings are large enough for permanent setting in forest plantations or windbreaks. They may be allowed to grow in the seed-bed another year without injury, but should be transplanted before the growth of the third season begins.

Seeds of Deciduous Trees that Ripen in Autumn may be sown to advantage in the autumn provided (1) the soil is not of such a nature as to become too solidly packed over them before spring; (2) they are not liable to dry up or wash out; or (3) they are not subject to injuries from rodents, insects, or other animals. In many locations some or all of these possible injuries may make spring sowing most desirable with most kinds of seeds. Our most successful nurserymen, however, prefer to sow in autumn, and to try to bring about the conditions that make it successful.

In the Matter of Storing Seeds it is difficult to lay down any exact rule to follow, and here, as in all other similar matters, considerable must be left to good judgment. As a rule, however, it is perfectly safe to winter over all of the seeds of hardy plants which ripen in autumn by burying them in sand out of doors.

Tree Seeds that Ripen in Autumn may be divided into four classes, which require different methods of treat-

ment to grow them, viz., dry seeds, seeds with fleshy coverings, nut seeds, and leguminous tree seeds.

Dry Seeds, like those of the Ash, Birch, Hard Maple, and Box-elder, are very certain to grow when sown in the spring in drills as soon as the soil can be easily worked, in the same way as recommended for Soft Maple and Elm. If not sown until spring they will have to be kept over winter, and, when only a small quantity is to be kept over, this is done best by spreading the seeds on the surface of the hard ground, covering with an inverted box and digging a ditch around it to carry off the water, or the seeds may be mixed with sand and kept in a dry, cool place. Large quantities may be kept on dry ground under a shed. These seeds will stand considerable drying, but if allowed to become very dry, hot, or moist their vitality may be injured or destroyed.

Seeds with Fleshy Coverings, as those of the Cherry and Plum, should be kept from getting dry before planting. The best way to handle them is to separate them from the pulp, mix with moist sand out of doors, and keep them moist until planted. It is generally safe to sow such seeds in the autumn on good land, but some growers prefer to sow them in the spring. This class of seeds should be frozen before germinating. If allowed to get dry before being frozen, they should be mixed with moist sand for a few days until plump, or they may be soaked in water, but care should be taken that they do not get water-soaked. Sometimes the dry, hard shells of such seeds seem to be waterproof. In this case, if the seeds are of special value, it is a good plan to file a hole through the shell, so as to let the seed become moist. Most seeds of this class grow the first year if properly handled, but some of them—for example, the Red Cedar and the Wild Thorn—even with the best management, will remain dormant in the ground for one year before growing.

Nut Seeds, as those of the Oak, Hickory, and Walnut, should be handled as recommended for seeds with fleshy coverings, but are more sensitive about being severely dried. As they do not transplant readily, it is very desirable to plant them where they are to remain permanently. They should be covered about two inches deep.

Seeds of Leguminous Trees, as those of the Black Locust, Honey Locust, and Coffee-tree, will stand severe drying for a long time and still grow provided they are treated with hot water just before planting. In this case the hot water should be poured over the seeds shortly before they are sown, and be allowed to stand until cool, when it will be found that some of the seeds have swollen up; these should be picked out and the remainder be treated again with hot water, and the process repeated until all have swollen. Seedlings of this class generally transplant readily, and are managed in the same way that is here recommended for the Ashes and Maples.

Seeds of Coniferous Trees, such as Pine, Spruce, Tamarack, and Arborvitæ, are dry and winged, but the Red Cedar has a fleshy, berry-like covering surrounding its seed. The seeds that grow in cones are most easily gathered before being shed from the cones. The cones should be gathered before they open, and then dried, after which those of most species will open and the seeds can be threshed out. Cones of a few trees, as those of the Jack Pine, will not open without artificial heat. These can be opened by gently heating them over a stove or in an oven to a temperature of from 100 to 150 degrees Fahr. Seeds of this class grow readily when sown, but must be very carefully stored or they will lose their vitality. They should be kept similarly to the seed of the Ash and Box-elder, but are more liable to injury than these kinds from too much moisture or heat, and for this reason

some careful growers prefer to always keep them mixed with dry sand in a cool shed.

The Seeds of the Red Cedar hang on the tree all winter, and must be picked by hand. They should be soaked in strong lye for twenty-four hours, the fleshy covering removed by rubbing them against a fine sieve, and then stratified in sand, where they will be frozen during the winter. Even with this treatment they will seldom grow until the second year.

Raising Coniferous Trees from Seed. The land selected for sowing the seed should have a light, porous surface soil, preferably underlaid with a moist subsoil that will not dry out easily. It should be so located as to have good circulation of air over it, that the plants may dry off quickly after rains, and it must be so shaded as to keep off about one-half of the sunlight. This latter permits a play of light and shade over the bed all day, and is about the condition under which we find nature raising such seedlings where trees partially shade the ground and protect them from the constant rays of the sun. In practice we aim to secure these conditions as follows: A piece of well-drained, rather sandy soil in an airy place is selected and laid out in beds four feet wide. In May the seeds are sown rather thickly (about three good seeds to a square inch), either broadcast or in rows, and covered with about one-fourth inch of sandy loam and then with about one-fourth inch of clear sand. Some of the small seeds, like those of White Spruce, should not be covered more than one-fourth inch. Before the seedlings break the ground, a framework at least three feet above the beds is made and covered with laths, laid about one and one-half inches apart, running north and south, or with sufficient brush to shut out about one-half the sunlight. If the bed is very much exposed to the winds it should have similar protection on all sides. In such

a place as this, or in woodlands where these conditions can be fulfilled, evergreens can be raised with much certainty, while if planted in the open ground, most kinds are sure to fail.

The Most Common Cause of Failure with those who try to raise Evergreens is what is known as "damping off," which occurs only while the plants are growing rapidly the first year. In such a case the seeds start well, and the seedlings grow vigorously for a short time, or until

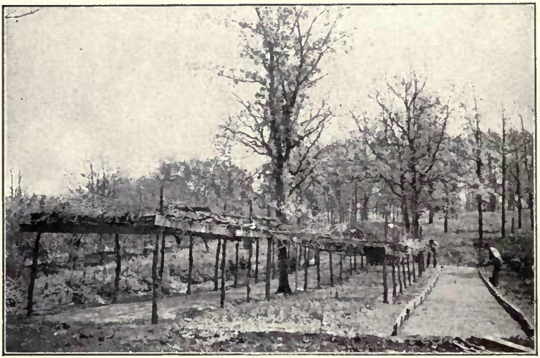

FIG. 23.—Evergreen seed-bed shaded with a screen of old brush placed on a frame.

we have a spell of damp weather, and then die off with great rapidity. It seems that the sunlight and the mud that has been spattered on the plants so weaken them that they are liable to disease. For this reason we shade the bed and cover with sand, which will not allow the mud to be spattered over the seedlings, and in very moist, warm weather we occasionally apply dry sand to dry off

the plants. For most kinds of conifers the shade is required for at least two years.

Most of the Coniferous Tree Seedlings Grow Very Slowly When Young, seldom making a growth of more than two or three inches the first year. The most rapid growing of our Pines seldom produce a growth of more than sixteen inches in four years, and should not be moved to their permanent place until about this time. They should, however, be transplanted from the seed-bed to a temporary place when two years old, to prevent crowding and to make a compact root-growth.

On the approach of winter, the beds of coniferous seedlings should be covered with about three inches of straw or leaves, evergreen branches, or other material that will afford protection from the sun and from alternate freezing and thawing. This should be removed in the spring after all danger from drying cold winds has passed.

Depth to Cover Seeds. Most of our tree seeds should, in good soil, be covered from one-half to three-quarters of an inch; but this is rather too much for such small seeds as the Birch, Alder, and Cottonwood, while the Black Walnut, native Plum, Acorns, and other large seeds and seeds of Box-elder, Ash, Soft Maple, and Basswood may often be covered two inches to advantage if the soil is somewhat dry. It is a good rule not to cover any tree seeds deeper than is necessary to secure permanent moisture, and on wet or heavy land only a very thin covering is desirable. If the land is very heavy, it is a good plan not only to cover lightly but to sow more thickly than usual, as a large number of seeds may be able to push up through the surface soil when a few would fail to do so.

The Amount of Seeds of Deciduous Trees to Sow on a given area depends very much on the kind and quality of the seeds and the soil in which they are to be sown. As

a rule, thick is better than thin sowing. The seeds of Box-elder, Ash, and Maple should be sown at the rate of about one good seed to the square inch; Elm and Birch should be sown twice as thick. Plums and cherries sown in drills should be allowed about one inch of row for each good seed. Black Walnut, Butternut, Hickory, and similar seeds should preferably be planted three or four in a place, and all but one seedling cut out when nicely started. If sown in drills, they should be placed from three to six inches apart. Rather thick seeding does not seem to be any hindrance to the making of a good growth by seedlings of most of our broad-leaved trees the first year, but if left thick in the seed-bed the second year they are often seriously stunted. On this account such seedlings should be transplanted or thinned out before the beginning of the second year. In nursery-planting it is a good plan to sow in freshly stirred land, as the seeds are far more likely to get a good start in it than in soil that has remained untilled long enough to become crusty and lumpy. Then, if the seeds are planted immediately after cultivation has been given, and while the soil is still moist, they have at least as good a chance as the weeds to start, while otherwise the weeds are soon ahead of the seedlings.

The Amount of Seed to Sow in order to obtain a given number of seedlings will depend upon the quality of the seed and on the soil and weather conditions at the time of sowng. The quality of seed varies much in different years and from different trees. The only way to be at all accurate is to test the seed, but as this is troublesome and the seed of most of our common trees is very cheap, it is seldom practised with them, and growers simply plan to sow two or three times as much seed as would theoretically produce the number of seedlings desired.

The Number of Seeds in a Pound varies greatly with

TABLE SHOWING THE APPROXIMATE HEIGHTS OF ONE-YEAR-OLD SEEDLINGS GROWN ON GOOD AVERAGE SOIL IN MINNESOTA.

Botanical Names.	Common Names.	Height in Inches.
Pinus strobus	White Pine	3
Pinus flexilis	Western White Pine	3
Pinus resinosa	Red Pine	3
Pinus divaricata	Jack Pine	3
Pinus ponderosa scopulorum	Rock Pine	3
Pinus sylvestris	Scotch Pine	3
Pinus laricio austriaca	Austrian Pine	3
Larix laricina	Tamarack	3
Larix europea	European Larch	3
Picea canadensis	White Spruce	2
Picea mariana	Black Spruce	2
Picea parryana	Blue Spruce	3
Picea engelmanni	Engelmann Spruce	3
Picea excelsa	Norway Spruce	2
Tsuga canadensis	Hemlock	3
Pseudotsuga taxifolia	Douglas Spruce	4
Abies balsamea	Balsam Fir	3
Abies concolor	White Fir	2
Thuja occidentalis	Arborvitæ	2
Juniperus virginiana	Red Cedar	3
Juniperus communis	Common Juniper	2
Juglans nigra	Black Walnut	12
Juglans cinerea	Butternut	12
Hicoria ovata	Shellbark Hickory	8
Hicoria minima	Bitternut Hickory	4
Salix nigra	Black Willow	10
Salix amygdaloides	Peachleaf Willow	10
Salix alba	White Willow	10
Salix lucida	Shining Willow	6
Populus tremuloides	Aspen	10
Populus grandidenta	Large-tooth Poplar	12
Populus balsamifera	Balsam Poplar	10
Populus deltoides	Cottonwood	16
Betula papyrifera	Canoe Birch	4–8
Betula alba	European White Birch	6–10
Betula lutea	Yellow Birch	4–8
Ostrya virginiana	Hop Hornbeam	4–6
Carpinus caroliniana	Blue Beach	4–6
Quercus alba	White Oak	4–8
Quercus macrocarpa	Bur Oak	4–8
Quercus rubra	Red Oak	6–12
Quercus coccinea	Scarlet Oak	6–12
Castanea dentata	Chestnut	6–12

TABLE SHOWING THE APPROXIMATE HEIGHTS OF ONE-YEAR-OLD SEEDLINGS GROWN ON GOOD AVERAGE SOIL IN MINNESOTA—(*Continued*).

Botanical Names.	Common Names.	Height in Inches.
Ulmus americana	White Elm	6–12
Ulmus racemosa	Cork Elm	6–10
Ulmus pubescens	Slippery Elm	10–20
Celtis occidentalis	Hackberry	8–10
Morus rubra	Red Mulberry	6–10
Morus alba tartarica	Russian Mulberry	6–12
Pyrus ioensis	Wild Crab	4–8
Pyrus americana	American Mountain Ash.	8
Pyrus sambucifolia	Elderleaf Mountain Ash.	4–8
Amelanchier canadensis	June-berry	8
Crataegus tomentosa	Black Thorn	4–8
Prunus americana	Wild Plum	15
Prunus pennsylvanica	Wild Red Cherry	12
Prunus serotina	Wild Black Cherry	12
Prunus virginiana	Choke Cherry	12
Gleditsia triacanthos	Honey Locust	8–12
Gymnocladus dioicus	Coffee-tree	8–12
Robinia pseudacacia	Locust	24
Acer saccharum	Sugar Maple	12
Acer platanoides	Norway Maple	12
Acer rubrum	Red Maple	10
Acer saccharinum	Soft Maple	24
Acer pennsylvanicum	Striped Maple	4
Acer tartaricum	Tartarian Maple	4
Acer negundo	Box-elder	12
Æsculus hippocastanum	Horse Chestnut	6
Æsculus glabra	Ohio Buckeye	4–6
Rhamnus catharticus	Buckthorn	6–12
Tilia americana	Basswood	6–12
Elæagnus angustifolia	Russian Olive	12
Fraxinus americana	White Ash	12
Fraxinus lanceolata	Green Ash	12
Fraxinus nigra	Black Ash	8
Catalpa speciosa	Hardy Catalpa	24
Viburnum lentago	Black Haw	4–6

size of seed and dryness. In the case of the Birch there are perhaps four hundred thousand; in Scotch, Shortleaf, Red Pine, and Norway Spruce there are perhaps seventy thousand; in White Pine about thirty thousand; in Box-

elder and White Ash about ten thousand; in Basswood and Sugar Maple about eight thousand; in Soft Maple about four thousand; in Black Walnut about twenty of the dry nuts in one pound and in Hickory Nuts from forty to sixty in a pound.

It is Important to Keep the Soil Loose and Mellow between the seedlings, and to keep the weeds very carefully removed until at least the middle of July, after which they may sometimes be left to advantage to afford winter protection; but in the case of very small seedlings this protection is best given by a light mulch, put on in autumn and taken off in spring, and the weeds should be kept out.

If the Seeds of Red Cedar, Black Thorn, Mountain Ash, and other seeds that require a long time to start are sown in the spring and do not germinate, it is a good plan to cover the bed with about an inch or two of hay or leaves, keep out weeds, and let this mulch remain until the following spring, when the seeds will probably be in condition to grow, and the mulch should then be removed.

CUTTINGS.

Cuttings are Pieces of the Branches or Roots which have the power of growing and forming new plants when placed in moist sand, soil, or other material. For example, the pieces of the twigs on branches of many kinds of Willows and Poplars, when taken while the tree is dormant, will root when placed in moist soil, but there are few other trees that grow as readily from cuttings as these. Cuttings of the roots of many kinds of trees, as the White Poplar, Wild Plum, Yellow Locust, and many others that sprout from the roots, will grow if treated about the same way as branch cuttings.

In growing plants from cuttings, the source of the cut-

tings is not of so great importance as the source of the seed from which the stock trees were grown, for the qualities of individual trees are probably not permanently or greatly changed by climate. For instance, trees grown from the cuttings of Russian Poplars would be as hardy in Dakota if the cuttings came from St. Louis, where they had been growing for years, as they would be if imported direct from Siberia. However, owing to a longer growing season at St. Louis, the wood might be of a more open texture, and perhaps might not resist cold as well as Minnesota-grown wood; but after one season's growth in Minnesota it would probably be as hardy. The same would hold true of plants propagated by any method of division. With the exception of Willows and Poplars, very few of our ornamental trees grow readily from cuttings. The best time to make cuttings is in the fall, as soon as the leaves will strip easily from the twigs. Most of the Willows and Poplars will grow readily from cuttings made in the spring, and even those made in summer will generally grow if planted in moist soil. For this purpose the smaller branches with the leaves removed should be used. They may also be rooted from growing twigs with the leaves left on, provided the cut surfaces are placed in water, as they should be if stuck in the soil of a swamp or treated the same as cuttings of geraniums. These latter ways, however, are not to be depended upon for general propagation purposes.

The Form and Size of Cuttings is a matter upon which there is great difference of opinion. Cuttings of the willow from one bud each and only an inch or two long up to those a foot or more in diameter and ten or twelve feet in length can generally be made to grow, but probably the most convenient size for general planting is one-half inch in diameter and twelve inches in length. They are generally tied in bunches of 100 or 200 each for con-

venience in handling, and care should be taken to keep all the butt ends one way to facilitate planting. Very large cuttings are liable to decay in the centre, and are not best to use, although they often make a very rapid growth. Poles of Willows and Poplars are sometimes laid in furrows where they will generally sprout wherever the bark is laid bare and often make good trees.

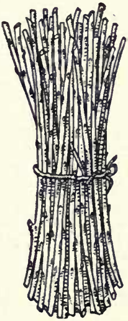

FIG. 24.—A bunch of Willow cuttings.

In Planting Cuttings of ordinary size it is a good plan to have the soil loose, and then after marking off the rows, the cuttings can be pushed into the land the proper depth. If not desirable to plough all the land, it may be loosened just where the rows are to come. Where a subsoil plough can be obtained, it can be made very useful for this purpose.

Cuttings should be planted at an angle of about forty-five degrees, leaving only one bud above the surface of the ground, and the soil should be packed firmly around

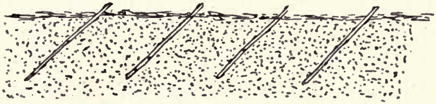

FIG. 25.—Planted cuttings, showing angle and depth at which to plant cuttings.

them. Those set in a slanting position settle with the soil and remain firm, while those set vertically may become loosened by the settling of the soil near them, leaving too much of them exposed above the surface, unless very great care is exercised in planting. The rows in the

nursery should be about four feet apart, and the cuttings about six inches apart in the rows, though a much less distance may sometimes be sufficient. In packing the soil over the cuttings great pains should be taken to get it very solid around the lower end, and if the soil is very dry, the firmest pressure of the full weight of a man over the base of each cutting is not too great; in fact, when the soil is dry, it cannot be made too firm over the cutting. When the soil is moist, however, only enough pressure should be used to bring the particles in close contact and close up the air-spaces.

The Cultivation of Cuttings should commence shortly after they are planted, and the top soil should be kept loosened to the depth of about three inches, which, while not disturbing the solid soil around the base of the cuttings, prevents evaporation from the soil.

Time of Planting Cuttings. Spring cuttings may be planted at once where they are to grow. Autumn cuttings may be planted out at once, provided the land is not wet, but when planted at this season they should be covered with soil turned toward them with a plough. In the spring this covering should be raked off before the buds swell. The ground being warm in autumn often causes autumn-planted cuttings of some kinds to root before cold weather sets in, and if made up before the first of October they may thus score quite a gain over spring-planted cuttings. If not desirable to plant in the autumn, the bundles of cuttings may be kept over winter buried in moist soil, preferably that which is somewhat sandy, where there is no standing water; but much care should be taken to keep them from drying out. To this end the bundles should be buried so as not to touch each other, and have two or three inches of soil packed in between them. If they are kept in a cellar, moist sawdust will be found to be good material to keep them in.

The amount of growth made by cuttings varies much, according to the kind of plant, size of cuttings, soil, etc. The most of our Willows will make a growth of three or four feet on good soil in one season from ordinary cuttings.

The Solar Pit. There are many trees that will not grow from cuttings unless they have their roots started a little before planting. This is most easily accomplished by means of what is called the "solar pit," which owes its success to the fact that cuttings root first at the warmer end. It is made and used as follows: The bundles of cuttings are heeled-in as recommended. In the spring they are taken out and buried close together, with the butt ends uppermost, in a warm, sunny spot and covered with about six inches of soil. A hotbed frame with sash is then put over the spot to warm the soil. Sometimes, instead of using sash, the soil over the cuttings is covered with a foot or more of fermenting manure. In either case the soil is warmed and the formation of roots encouraged. In using the solar pit, the rooting process should not be carried so far as to permit roots to show plainly, as they are liable to be broken off in planting out; but the cuttings should be planted out as soon as they show signs of heeling over on the butt end. This heeling-over process is called **callousing,** and in many plants necessarily precedes the formation of roots.

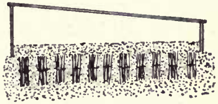

Fig. 26.—The solar pit, showing bundles of cuttings in place under glass.

LAYERS.

Layers are portions of the branches of trees, shrubs, or vines which are covered with earth without being

separated from the parent plant and there take root and grow. These are cut off from the main plant in autumn or spring and form new plants. Almost all trees and other plants can be rooted in this way, but while some root very easily, others require so long a time to do so as to make it impracticable with them.

The growing of trees from layers is seldom practised in this country, but in some European nurseries it is a common means by which to increase special varieties of trees. For this purpose what is commonly known as mound-layering is often used. This consists simply of

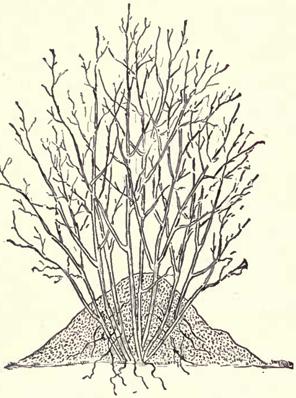

FIG. 27.—Showing method of mound-layering.

drawing the soil up around the sprouts that come from the stump of a tree, covering the base of them about a foot in depth. It may be done at any time of the year after the sprouts are two or more feet high, but preferably in the spring. After the sprouts have become

well rooted, they may be removed in spring or autumn and treated the same as seedlings. Layering is sometimes practised in European forests to fill up vacancies, and a similar method is often employed in nurseries.

GRAFTAGE.

Graftage refers to the growing of one plant on the stem, root, or branch of another plant. There are several forms of graftage, which are generally known as grafting, budding, and inarching. It is a common practice to use graftage in the growing of the different varieties of fruit-trees, and it is also used to some extent in the growing of some of the varieties of ornamental trees that cannot be grown from seed. Trees that are grown by any form of graftage are seldom as long-lived as those grown on their own roots, and these methods should be avoided when it is practicable to do so. These methods are not much used in common practice and consequently are not discussed at length here.

Inarching is a rather unusual way of growing plants. It works on the principle that when the growing stems, branches, and roots of the same or closely allied plants are held closely together for some time they become united. Such unions of roots are frequently found in woodlands; in some cases the roots of the same trees, and in others the roots of different trees, become grown together. Occasionally trees are found grown together by their branches or stems. Inarching is sometimes used for growing the Cutleaf Birch, in which case the sprouts from a stump of a Cutleaf Birch, or the twigs from a small tree laid on the ground, are tied to small Birch seedlings which have been grown in pots and plunged to their rims in the ground near the tree. In doing this the bark is removed for about two inches at the point

of contact of the twig and seedling, which are then tied firmly together. It should be done by the middle of June, but will often be successful if done even a month later. They should be kept together until the leaves fall, and then the branches from the parent tree should be cut away, leaving the seedlings with the twigs grown fast to them. These should be carefully heeled-in over winter, and in the spring the seedlings should be cut off just above the union, so as to throw all their strength into the adopted twig of the Cutleaf Birch. This method may also be used to replace lost branches on trees or vines.

CHAPTER VII.

NURSERY PRACTICE.

Nursery. This term is applied to a plot of land used for raising plants that are intended for planting elsewhere for their final growth.

Soil and Cultivation. The best soil for a general nursery is a deep, rich, reasonably level, retentive upland. It is customary to grow most of the nursery crops in rows, so that they may be readily cultivated. The land should be ploughed deeply when the crop is planted and the surface soil kept loose and fine during all the early part of the growing season, or until about the middle of July. If the land that has to be used for a nursery is rather shallow, it should be gradually deepened by ploughing from year to year, and if inclined to dry out the addition of large quantities of organic matter, together with constant cultivation, will do much to remedy these defects.

The cultivation of a nursery or young forest plantation, provided the latter is planted in rows, should be much the same as for garden crops and consists in keeping the land stirred to the depth of three inches, thus giving a dust blanket, which will protect from drought. After the first of August much cultivation is likely to encourage a late autumn growth, which should be avoided; but a moderate quantity of buckwheat or oats may be sown then and be allowed to grow the remainder of the season, to serve as a winter protection—to hold snows and prevent the heaving out of the young seedlings by frost.

GRADES OF NURSERY STOCK.

Nursery stock of different kinds has come to be known by such convenient names as seedlings, transplants, street trees, forest-pulled seedlings, etc.

Seedlings are young plants, grown from seed, that have never been transplanted, and are generally designated

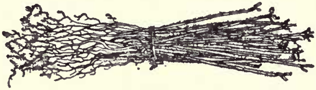

FIG. 28.—A bunch of Green Ash Seedlings.

by their size or age. They form the cheapest class of nursery stock, and are used largely for starting windbreaks.

Transplants are seedlings that have been at least once transplanted, and are designated by their size and the number of times they have been moved. They are higher in price than seedlings, but with some kinds of trees they are much more likely to grow, and may be well worth the extra price. Evergreens, especially Pines, will seldom do well unless once transplanted before being set in a permanent place.

Street Trees include the trees of large size which are used for street, shade, and ornamental purposes. To be of the best quality they should have been transplanted two or more times and have received some attention in the way of pruning so as to give them a good form. Such trees vary much in quality and price, but the best are necessarily rather expensive.

Forest-pulled Deciduous Trees of small size can often be obtained at a very low price, and may be as desirable as those that are nursery grown.

Forest-pulled Evergreen Seedlings of Small Size may also be desirable, but too often they have poor roots, or have been so injured by poor handling that they are worthless. They should have their roots carefully protected at all times.

Forest-pulled Shade Trees sometimes grow very well, but they are always inferior to good nursery-grown trees. They are generally improved by having their roots shortened two years before they are to be removed, and when so treated grow very well.

TRANSPLANTING.

Transplanting is Simply the Removal of the Plant. It may be to some permanent place, as a park, lawn, or street, or it may be done for the purpose of improving the root system and to give the tree more room to grow. By shortening the long roots the root system is made more compact and better able to withstand subsequent removal. This may be done by transplanting, or by cutting around the tree with a spade or tree-digger. It is especially desirable to do this to trees that are not easily moved on account of their long branching roots, such as the Birch, or to those that have tap-roots, like the Oak and Walnut. It is on account of their having had their roots shortened so that the root system is compact and can all be moved with the tree that nursery-grown trees are generally superior to others.

In Transplanting it is Important to take up a sufficient amount of roots to support the plant, and as a rule the more roots the better the conditions for growth. Very long roots should be shortened unless the tree is removed to a permanent place, in which case all the good roots should be left on the tree. All bruised or broken roots should be cut off in either case and the top of the

tree shortened to correspond. In transplanting trees, they should be set at least one or two inches lower in the soil than they formerly stood, and the roots should

FIG. 29.—Extra-good roots on a forest-grown Elm, used as a street tree.

be spread out in the holes without crowding. It is customary to plant many kinds of small trees in furrows made with a plough.

Very Large Trees (those over six inches in diameter) are sometimes successfully planted in winter by taking them up with a ball of earth. This is done by digging a trench around the tree, late in the autumn, deep enough to cut most of the roots, but far enough away from the tree to leave a large ball of earth. The trench is then filled in with a mulch of some kind, and when the ground is frozen the tree is moved, with the ball of earth attached, to the hole which has been previously prepared and kept free from frost.

After Trees Have Been Moved, or had their roots shortened in some other way, they should generally not be transplanted again for at least one or two years, during which time they will have overcome the injuries done to their root system. The time which should thus elapse

will vary with the kind of tree, and also with the amount of injury done. Where the injury is severe a much longer time will be required for recovery than where it is slight.

Time to Transplant. Planting of trees should always be done when they are dormant, or just as they start into growth in the spring, which is generally from the middle to last of April. If for any reason it is desirable

FIG. 30.—Moving large trees in winter. (After P. S. Peterson & Co.)

to risk the moving of trees late in the spring, after the leaves have started, they should be cut back severely, all the leaves removed, and great pains be taken to secure all the roots and to prevent their drying out. Very hardy deciduous trees, as the Elm, Cottonwood, Boxelder and Ash, can often be successfully moved in the fall if the ground is moist at the time of removal, but great care must be taken to work the soil in very com-

pactly between the roots, so that there will be no large air-spaces among them. If the trees are large, it is a good plan to stake them, so they cannot be blown about by the wind. The more tender trees should not be transplanted in the Northern States in autumn, and even the hardiest kinds should never be moved at this season unless the soil is moist.

Transplanting Evergreens. When seedling cone-bearing Evergreens are two years old they should be transplanted, and this should be done about once in three years afterwards, until they are moved to their permanent places. As Evergreens are very sensitive to being moved, this requires more care than with most deciduous trees. The most important point is to not allow the roots to have even the appearance of being dry. In handling small Evergreens in the field it is often a good plan to keep them in a pail containing enough water to cover their roots or keep them in wet moss. They may be transplanted in the spring, as soon as the ground works easily and the roots have white tips, and they may be safely transplanted even up to the time that the new growth shows three inches, but at this late date more care must be taken in doing the work than when it is done earlier. Evergreens can sometimes be moved successfully in August, or even in the autumn, if they are to be carried only a short distance and the conditions of the weather and land are favorable; but this is not a time for general planting, and it is seldom advisable to do it at this season.

The Very General Error is Current that June is the best time to plant out Evergreens. They may be transplanted at this season successfully if the conditions are just right in every particular, but they are much more liable to fail then than when the work is done earlier in the season. At whatever time of the year Evergreens

are to be moved, the work should be done in such a manner as to protect the roots from having even the appearance of being dry, for if dried ever so little the probabilities of their living are much lessened. The kind of treatment that would be considered all right for Apple-trees might be fatal to Evergreens, as they are much more susceptible to injury from drying.

In addition to the above precautions to be taken when moving Evergreens, it is desirable to shorten back the limbs about one-third, to compensate for the loss of roots. Of course this shortening should not be done in such a way as to disfigure the tree, but when the roots are in any way severely mutilated, the whole top makes more of a draft on them for moisture than the roots can supply. This pruning is not so necessary in the case of young seedling Evergreens or nursery-grown trees that have been recently transplanted, for when they are moved their root systems are not seriously injured.

Very Small Evergreens and Other Small Plants are often set in trenches made with a spade, as shown in Fig. 31. For this method the soil must be loose and yet sufficiently compact so that it can be cut with a spade and not crumble before the plants can be set out. The beds are made about six feet wide, and a board of this length and six inches wide should be used. The soil is thrown out with a spade (*A*) to the depth of about six inches, but no wider than necessary to just take in the roots. The plants are then placed in position by hand and a little soil pushed against them to hold them in place. (*B*) The trench is then half filled and the soil firmly compacted by the feet. The remainder of the soil is then put in and levelled off, the board is changed to the other side of the row first planted, and the planting is continued in the same way (*C* and *D*). Such close planting as this is only desirable when it is intended to

give special care to the plants, as by shading or watering. Plants should not remain more than two or three years in so close a bed before they are transplanted. When it is desirable to set out small seedlings in rows, instead of beds, a tight line may be used in place of the board.

Heeling-in. This term is applied to the temporary covering of the roots of trees with earth to keep them from drying out after they are dug and until they are planted. If they are to be kept for only a few days,

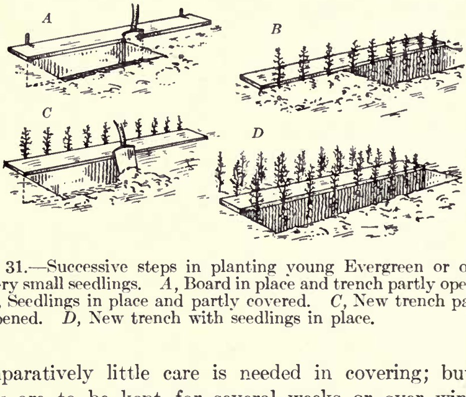

FIG. 31.—Successive steps in planting young Evergreen or other very small seedlings. *A*, Board in place and trench partly opened. *B*, Seedlings in place and partly covered. *C*, New trench partly opened. *D*, New trench with seedlings in place.

comparatively little care is needed in covering; but if they are to be kept for several weeks or over winter, especially if the weather is dry, great care must be taken to work the fine soil in among the roots and to pack it solid. A good way of doing this is as follows: Select a dry, mellow piece of ground and dig a trench just large enough to take in the roots of the trees when laid close together in a single row. Place the trees or seedlings in this trench in an upright position, a few at a time, and cover the roots firmly and deeply with soil taken from

close in front of the first trench, thus making a trench for the next row. If trees that are of questionable hardiness are to remain heeled-in all winter, it is a good plan to bend the tops down and cover with earth. This is only necessary for winter protection. The neglect to properly heel-in nursery stock as soon as it is received is undoubtedly a frequent cause of failure. This is especially so in the case of seedlings which are generally wintered in bundles, as they are liable to dry out in winter. The bundles must be opened if large, and in any case the soil should be packed in around them very solid by the feet or otherwise.

Trees and Cuttings Will Sometimes Get so Dry in shipment that the bark shrivels. In such cases the best treatment is to bury them entirely for a few days, which

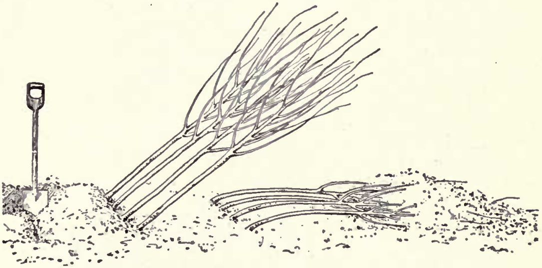

FIG. 32.—Heeling-in. Various stages of the operation. Row of trees with roots covered; row bent down and the tops covered.

will often enable them to recover. Soaking in water will answer the same purpose, but unless very carefully done is likely to injure the wood.

PRUNING.

Pruning Should be Avoided as much as possible and yet be done sufficiently to secure the effect desired. If it is begun early in the life of a tree no large branches need ever be removed, the most desirable pruning being the directing of the growth by pinching off the buds that would develop into undesirable branches; but this is impracticable on a large scale, and for this reason, in ordinary practice, it is often necessary to do more extensive pruning.

The Purpose in Pruning Trees is to give them forms that are desirable for the purpose intended. For example, a tree for the lawn or windbreak may be most desirable when covered with branches even down to the ground, while street trees should have a trunk free from branches for eight or ten feet from the ground. Many of the Evergreens, and some other trees used for ornament, naturally take on so regular and desirable a form that it is not necessary to prune them, except perhaps to pinch or cut off an extra leading shoot that is likely to make a forked top, while the White Elm, Soft Maple, and others need occasional pruning to remove or shorten awkward branches, at least while the tree is young and growing rapidly.

The Proper Time for Pruning is determined by the effect of the operation upon the health of the tree. Dead branches may be safely removed at any season. The removal of live branches during the growing season lessens the leaf surface and hence checks growth. Pruning when the tree is dormant results in a more vigorous growth in the remaining branches. Wounds made by pruning just as trees are starting into growth do not heal over as readily as those made earlier in the spring or during the period of active growth in June. Wounds made

in autumn or early winter generally heal over well, but are more likely to cause bad injuries than if made at the close of the winter. These considerations and practical experience have brought about the following conclusions as to the best time for pruning:

Large Branches are Most Safely Removed during the latter part of winter, before growth starts. Small branches may be safely removed at this time, or during the growing season, preferably about the middle of June; but

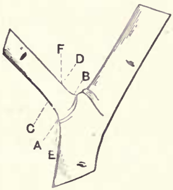

Fig. 33.—Showing the proper place to make the cut in pruning. A wound made on the dotted line *A—B* will be promptly healed; one made on the line *C—D* or *E—F* will not. In Fig. 34 the lower branch was cut off too far from the trunk. (After Goff.)

such very hardy trees as the Elm, Ash, Box-elder, White Willow, Catalpa, and Cottonwood may be safely pruned at any time in autumn, winter, or spring, while the Mountain Ash, Apple, Plum, and Wild Cherry are liable to injury if pruned at any but the most favorable seasons.

Among the Directions to be Followed in Good Pruning are the following:

1. Do not cut off a single branch unless you have a good idea of what you wish to accomplish and the probable effect of so doing on the tree; better not prune at all than to do it without considering the consequences.

2. Avoid doing very much pruning at one time, especially on small street trees, which, if they have all

their branches removed from the trunks to their final height, are likely to make too much growth at the top for the trunk to support well in high winds. A better way is to remove a part of the lower branches and shorten back in summer those that are to be removed later; by such treatment a large part of the strength of the tree goes into the top without increasing the size of the lower branches, which may be removed in a year or two without injury to the tree.

3. After pruning, paint the wounds with good white lead paint, to keep the wood from decaying and the in-

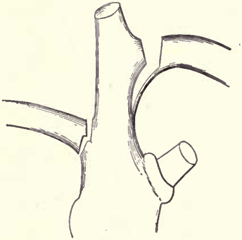

Fig. 34.—Showing how to make the cut in pruning large branches. The upper cut, all made from above, permits the branch to split down. The left cut, first made partly from below, prevents splitting down. (After Goff.)

juries from becoming permanent. This is not so necessary on very hardy trees as on those that are somewhat tender.

4. Where branches rub together, it is generally best to remove one of them.

5. Where bad crotches are being formed by the development of two leaders, severely check the growth of one of them by shortening it, thus throwing more sap into the other and making it the leading shoot.

6. Prevent the formation of long side branches by shortening those that are liable to become too long. This is especially desirable with the Soft Maple, which has a tendency to form long branches that are likely to break off unless occasionally pruned.

7. Where trees have lost their leaders, prune so as to develop one of the side branches into a leading shoot.

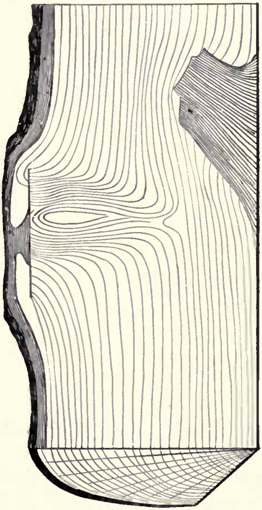

Fig. 35.—Sections of trunk of tree showing wounds properly healed over. (After Hartig.)

This the tree always attempts to do itself, but a little judicious pruning will greatly aid it.

8. Every species of tree and shrub has its own natural form, and in pruning do not try to make all of them

of one shape. Study the natural form of each kind of tree and encourage the development of this form.

9. When trees are full of frost the wood cracks very easily; therefore do not prune in very cold weather, for bad wounds may then be easily formed.

Treatment of Crooked Trees. It is common to have some trees in the nursery that are of vigorous, healthy growth, but so crooked as to be nearly worthless. The proper treatment for most of our shade trees when in this condition in the nursery, if anything is to be made of them, is to cut them off at the surface of the ground early in the spring and then select one of the good, strong sprouts that come from near the roots of each tree, train it into a straight stem, and cut away the others. Treated in this way well-formed trees may soon be grown. Such treatment may also be desirable with small street trees that have their stems hopelessly injured. However, trees that to the novice may seem hopelessly crooked may only have crooks in them that will be outgrown in a few years.

STREET TREES.

Success with Street Trees is perhaps more dependent on good soil about the roots than on any other one factor. If the land is so very sandy or gravelly as to be subject to drought, at least two cubic yards (two full two-horse loads) should be taken from where each tree is to be planted and the same amount of good clay or loam substituted for it. If in subsequent years the trees outgrow the limits of the material supplied, more of it should be added, and if this consists largely of stable manure, so much the better, provided it does not come into contact with the roots of the trees. It is important to do this work

thoroughly, for one tree well planted is better than a dozen poorly set out.

Kinds of Trees. The best trees for street planting in this country are the White Elm, Hackberry, Green Ash, Basswood, Box-elder, Norway Maple, and Soft Maple. All of these trees do well in good soil, and with the exception of the Soft Maple they all do well in rather inferior land. Evergreens, especially the White Pine, may sometimes be used to advantage along narrow drives, but they are seldom desirable as street trees. The trees planted should be about two to four inches in diameter near the ground, eight or ten feet high, and of thrifty growth. Much larger trees are sometimes set out, but it is not advisable, as a rule, to plant those that are over four inches in diameter. Smaller trees are often planted and do well if properly cared for, but need more attention directing their growth than those that are larger. But small, thrifty trees are much better for street planting than large stunted trees. In all cases it is more important to have plenty of good roots than a large top, as a top can soon be developed if the roots are good.

Distance Apart. The distance between trees depends on the kind planted and the quality of the land. On rich land the trees named should be put forty feet apart, in fairly good soil about thirty feet, and in poor soil twenty feet apart. This gives sufficient room for good development, but where a quick effect is wanted, it is a good plan to set the permanent trees forty feet apart and use Cottonwood, Willow, or similar fast-growing trees to alternate with one of the kinds named as desirable, with the expectation of cutting out the less valuable when it shall have commenced to crowd the more desirable kinds.

Planting. Provided the soil is in the proper condition, the next consideration is the proper planting of the tree.

The preparation for this should consist in digging a hole of sufficient size to take in the roots without crowding. If the subsoil is very solid clay, it should be thoroughly loosened up, and where practicable, it is a good plan to dig a trench to the loose soil over a water pipe or sewer, for by this means the roots get into loose soil, and drainage is secure, which is often much needed on such land.

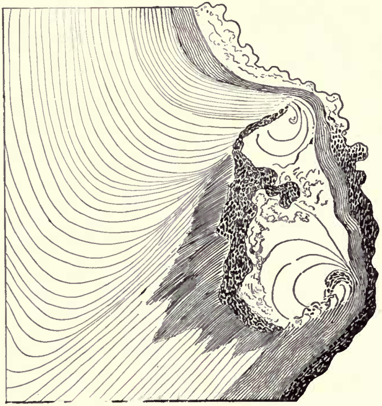

FIG. 36.—An overgrown wound where branch has been cut off, but decay started before wound had healed over and is liable to continue farther. (After Hartig.)

Sometimes a very stiff hardpan can be broken up to advantage by exploding a small dynamite cartridge in a deep hole made with a crowbar.

Before Setting the tree it should have all broken and dead roots cut off. It should then be set an inch or two deeper than it had been growing, the discoloration above the roots indicating the depth at which it had stood. If, however, good drainage cannot be secured, the tree

can be planted less deeply and then have a mound made around it. Fill in about the roots slowly, being careful (should the tree have a great number of fibrous roots) to work the earth well in among them and under the butt of the tree. Fine soil free from large stones should be used for this purpose. Pack the soil in firmly, if reasonably dry, with the heels, or, better still, with a rammer, making it as solid as possible around the roots. The object in doing this is to leave no air-spaces about them. It is not a good plan to put water into the hole before

FIG. 37.

FIG. 38.

FIG. 39.

FIG. 37.—Soft Maple not pruned since it was planted out. Liable to break in its crotches at any time. A bad form.

FIG. 38.—Soft Maple once pruned, showing close head that is not liable to break down. A good form.

FIG. 39.—Soft Maple several times pruned, preserving a main central axis. A good form.

the tree is set, but it may be put in when the roots are just covered and allowed to soak away before the remaining soil is put in. As a rule, however, little is gained by watering if the trees have not leaved out and the moist soil is packed firmly around the roots. Water is most needed after growth starts.

Mulching. Newly planted street trees are much helped by a mulch of straw, hay, or well-rotted manure. The latter is best, as it also furnishes plant food, and hot manure is liable to injure the trunk if piled against it. These materials prevent the soil from drying out, and is especially beneficial if the trees are artificially watered.

Watering should be done thoroughly or not at all. One good watering should keep the ground moist for two or three weeks, in the dryest weather we have, if the land is heavily mulched when the water is applied. For a good watering in a dry time at least one barrel of water should be given to each street or lawn tree, and for large trees very much more water should be used. A hollow should be made around the tree and covered with mulch before the water is applied. This same amount of water might be applied at the rate of one or two pailfuls a day and not be of the least benefit to the tree if applied to the bare surface of the ground.

Fig. 40.—Elm street tree properly trimmed for planting out.

The Pruning of Deciduous Street Trees at the time they are set out is an important matter. If the trees are very tall and slender, it is a good plan to cut them off at about ten feet from the ground and trim off all side branches, as shown in Fig. 40. For trees that have been pulled from the woods this is generally the best treatment, while for nursery-grown trees that have had plenty of room to develop a good top, it may sometimes be best to trim so as to leave part of the top. If the trees are trimmed to bare poles before planting, some little pruning will be required each season

for a number of years to develop good tops, while if they had well-formed tops in the nursery and were shortened back at planting time much less attention will be necessary, but the experience of large planters seems to show best results from close pruning.

In a row of Elms or other trees there will often be found peculiar individual shapes. Some of the trees will take on desirable forms, while others will be spreading and awkward, and perhaps have a tendency to crack

FIG. 41.—Elm-tree that has been planted five years and was pruned to a bare pole when set out.

in the crotches. In some cases a little extra pruning will bring such unfortunates into shape, but often they are incorrigible, and are best replaced by other trees with better forms.

Protection should always be given street trees as soon as they are set out, and this should consist of something that will protect them from sun-scald, gnawing of horses,

and whittling by thoughtless boys. A good temporary cover is afforded by wrapping the trunk with gunny sacking or similar material, but a more desirable protection is afforded by a slatted wooden frame or box for each tree.

The Packing of Nursery Stock is a matter that calls for much experience to adapt it to the various kinds of nursery stock shipped and to the method of transportation.

Practically all the nursery stock that is used in forest-planting in this country is best shipped when dormant.

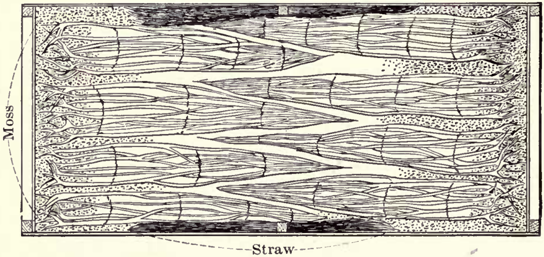

Fig. 42.—Cross-section of a box packed with two-year-old Green Ash, Box-elder, and Birch in bundles of 100 each.

It will generally be found that the box is the safest package to use in the handling of it, but sometimes it may be convenient to ship in bales. Small packages may be sent in bundles or in boxes by mail, and for this purpose they can best be packed in clean sphagnum moss, wrapped with oil-paper and afterward with brown paper. Packages that are to go by express do not require as careful packing as those that are to go by freight, as they are not so liable to be neglected. In shipping by freight it

is important to pack with exceeding care, so that the goods will be safe even if considerably delayed.

Puddling. All dormant nursery stock should have the roots "puddled" before being shipped. This operation consists in dipping the roots of the trees into a thin clay mud. A convenient way to do this is to dig a small deep hole in which the mud is prepared. Such treatment is quite a protection to the roots against drought.

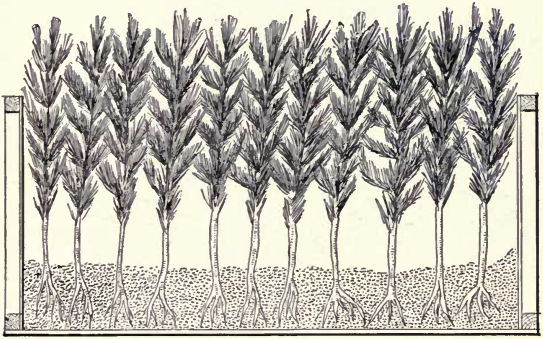

FIG. 43.—Cross-section of a box packed with Pine Seedlings. The roots are covered with moist sphagnum moss, and the tops are not covered. In actual practice the plants would be much closer together.

The Best Material in which to pack nursery stock is probably moist (not wet) sphagnum moss, but as this is often expensive and out of the question in many localities, peat, excelsior, or wet chaff will be found good substitutes. Of late years excelsior has been growing in favor with our best nurserymen as packing material. The material used for this purpose is such as is generally wasted at shingle mills. Before using, it should be thor-

oughly water-soaked. It has the advantage of not heating and yet retaining moisture for a long time.

Nursery Stock in Transit is liable to several injuries. One of the most common is for it to become too dry and in this way lose its vitality; and yet it often happens in shipping nursery stock that is to be several weeks in transit that it is best to pack it so dry that the plants will perhaps shrivel a little, since if packed moist it will

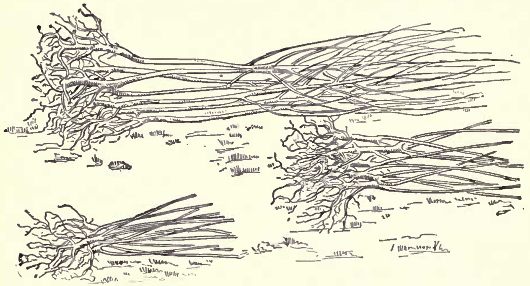

FIG. 44.—Plants assembled together for packing in a bale.

often decay. When moss is to be used for packages that are liable to be a month or more on the way, it should be thoroughly dried so that there will be little moisture apparent in handling it. In such cases the boxes should be thoroughly lined with paper before they are packed. Paper lining for boxes is also very desirable when nursery stock is to be shipped during excessively cold weather, as it aids greatly in keeping out frost.

In shipping nursery stock in warm weather it may sometimes be desirable in the case of evergreens to pack the roots in moist moss and leave the tops exposed, shipping the box without any cover, or if covered at all, using only burlap or similar material. In packing such a box

it is a good plan to remove one end and pack in alternate layers of packing material and plants, and when the box is full nail on the end. In this way the plants can be put in very solid. Fig. 43 shows this method.

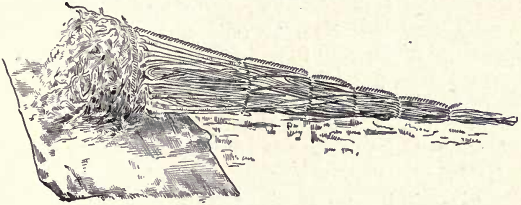

FIG. 45.—The bale ready for covering.

It is Customary to Have Seedlings tied in bunches of about 100 each when they are shipped, and whenever small stock is shipped with large stock it should be in a separate bundle. It is seldom necessary or desirable to put packing material about the tops, but it should be confined to the roots and the centre of the bundles, and the tops should be left somewhat free, so they will not heat. In packing nursery stock in this way it may be

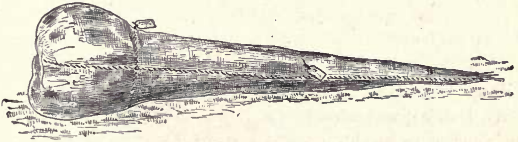

FIG. 46.—The bale completed by covering with burlap and labelled for shipping.

desirable to carefully nail cleats across the box after the stock has been put in, to hold it in place and prevent its shifting about in transit, and sometimes it may be desirable to ventilate the cases in which they are packed.

In Packing a Bundle great care should be taken that the packing material is well worked in between and around the roots, so as to exclude a free circulation of air about them. After this has been done, and the package well tied together, it should be covered about the roots with more packing material and wrapped with burlap or similar material well sewed on, and the tops should be protected either with burlap or with straw or grass.

SOME IMPORTANT THINGS TO REMEMBER ARE:

1. *If the roots of trees are frozen* out of the ground and thawed again in contact with the air, they will probably die.

2. *If the frozen roots of hardy plants* are well buried in the ground before thawing at all, they will be uninjured.

3. *Deciduous trees* that are received in a *shrivelled condition* may often be revived by burying them, tops and all, with earth for a few days.

4. *Manure should never be placed* in contact with the roots of trees when they are set, but good black soil should preferably be used for this purpose.

5. *If trees are watered* it is important to keep the soil around them cultivated or covered with a good mulch, otherwise the surface will bake hard and will lose moisture very fast.

6. *Small thrifty trees are* very much to be preferred for transplanting purposes to those that are large, as the latter are liable to be checked in their growth by being moved.

7. *The roots of coniferous* Evergreens should not be allowed to have even the appearance of dryness, as a very little drying will prevent their growing.

8. *Spring is the best time to move* all kinds of nursery

stock, and as a rule plants do best when transplanted before the buds start.

9. *Autumn is a good time* for transplanting our hardiest deciduous trees providing that the soil conditions are favorable. but it is not a good time to move coniferous Evergreens.

10. *Coniferous Evergreens* may be safely moved about the first of August, after they have ripened up the first growth of the season, if moved carefully with a ball of earth, but when handled at this time they require much careful attention.

CHAPTER VIII.

FOREST PROTECTION.

INJURIES TO TREES.

THE causes of injury to tree-growth are many and various, some affecting principally the cultivated trees in windbreaks and shelter-belts, and others affecting the forest plantations and large areas of timber. Some injure or destroy the trees or tree seeds, and others do damage to the land on which they grow.

Insects occasionally do an immense amount of damage to forests, and it is often impracticable to combat them successfully on a large scale. We must often, therefore, depend on their natural enemies to hold these pests in check. It is seldom, however, that insects of any one kind are very abundant over a long series of years, but they are occasionally nearly destroyed by the multiplication of their parasites or other natural enemies.

Saw-Flies and Tent-Caterpillars. At present perhaps one of the most serious injuries to cultivated trees results from the neglect to take precautions against leaf-eating insects, such as saw-flies and tent-caterpillars. These injuries may be largely prevented by the use of Paris green in water applied by means of a force pump, using it from a barrel carried in a wagon or on a stone boat. An ordinary spraying nozzle should be used, with a sufficient length of hose to reach up into the tree. In order to reach the tops of the trees it may be necessary to have

a raised platform on the wagon, and to attach the hose nozzle to the end of a long bamboo pole. In most prairie groves, this is practicable, but with very high trees it is very difficult, if not entirely impracticable. For most leaf-eating insects, Paris green is best applied in water at the rate of one pound of poison to 150 gallons of water. When used dry, mix with cheap flour at the rate of one pound of poison to thirty pounds of flour or one pound of Paris green to 100 pounds of air-slaked lime.

For Sucking Insects, such as plant lice and Box-elder bugs, Paris green is worthless, and the remedies used

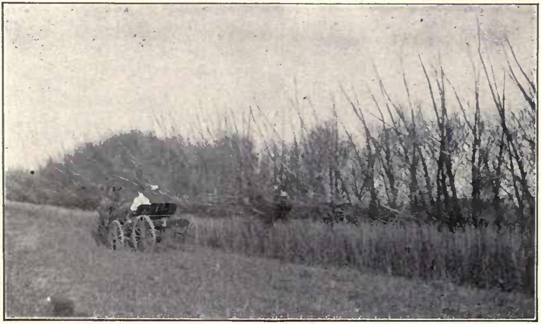

FIG. 47—White Willow windbreak seriously injured by successive attacks of saw-fly larvæ.

must be those that will kill by contact, such as tobacco water made the color of strong tea, whale-oil soap, and kerosene emulsion. In the case of small trees that can be easily enclosed in a tent the best remedy is tobacco smoke.

Borers Cause much loss in forests by tunnelling through the wood. They generally prefer trees that are some-

what weakened, and such trees may occasionally be left as traps, and when badly infested burned, and in this way large numbers of borers of some kinds may be destroyed. Trees that are badly attacked should as a rule be removed.

Mice and Rabbits. Seedlings and small trees of some kinds are liable to injury from rodents, such as mice and rabbits, which gnaw the bark near the surface of the ground and perhaps girdle the tree. They are most likely to do this when the ground is covered with snow, for this furnishes them with a protection under which they can do their mischief without fear of being molested. In the case of small seedlings, such injuries may be largely prevented by ploughing a furrow or setting boards on edge around the seed-bed. If, after each snowfall, the snow is trodden down so as to make a solid path between the seedlings and the grass or woodland whence the mice come, they will be kept out, as they will not try to work through the solid snow. Seedlings that are badly girdled in winter should generally be cut off at the surface of the ground, to encourage sprouts from the roots. To prevent the gnawing of larger trees, paint the trunks with a cement or lime wash made rather thick and containing Paris green in the proportion of one tablespoonful of Paris green to a pailful of the wash. If skim-milk is used in mixing the wash, instead of water, the material sticks better. Trees that are gnawed badly may often be saved by coating the injured surface with grafting-wax, blue clay, or other similar material, soon after the damage is done, so as to prevent the seasoning of the wood, and thus give it a chance to heal over. Where the injury is close to the ground, it should be covered with earth.

The Pocket Gopher. Trees are sometimes injured by pocket gophers eating the roots. Trapping or poison-

ing may be resorted to, or bisulphide of carbon may be used to suffocate them in their burrows.

Birds. Most of our birds are helpful in various ways, such as distributing seeds and in destroying injurious insects, and such small injurious animals as mice and gophers. They also add to the beauty of our woods and fields, and to our pleasure and recreation. But some kinds are provokingly injurious by eating the seeds we wish to gather, or by digging up newly sown seeds. Where they are troublesome on seed-beds, they may be kept away by covering the bed with wire netting, which will also serve to keep away other animals. If only birds are troublesome, mosquito netting may be used, or the seeds may be given a light coating of red lead and dried in land plaster or flour before sowing.

The sap-sucker does considerable injury to some trees by making holes in the bark for the purpose of securing insects which go there to feed on the sap. They are sometimes so very injurious that it is necessary to destroy them. The Apple, Box-elder, Maple, and most other trees are subject to their injuries.

Cattle. The pasturing of cows, horses, sheep, and other animals in the woodlands is generally a poor practice, as these animals browse off many of the young seedlings, especially those of deciduous trees, such as the Oak, Basswood, Cherry, and others, though they seldom eat coniferous trees. They also compact the ground, and destroy many small seedlings by their continued tramping, especially when present in large numbers. This is especially true of sheep on the Western forest reserves. Deer, moose, elk, and other similar animals are likewise injurious in forests, and when abundant may do much damage, though on account of their comparatively small number they seldom do more than slight injury.

Forest and Pasture. When forests are used as pas-

ture, the cattle will eat the foliage of many species, provided it is within their reach. They also trample on the young seedlings and destroy them in this way. As a result, all good foresters are, on general principles, opposed to the pasturing of cattle in woodlands. Espe-

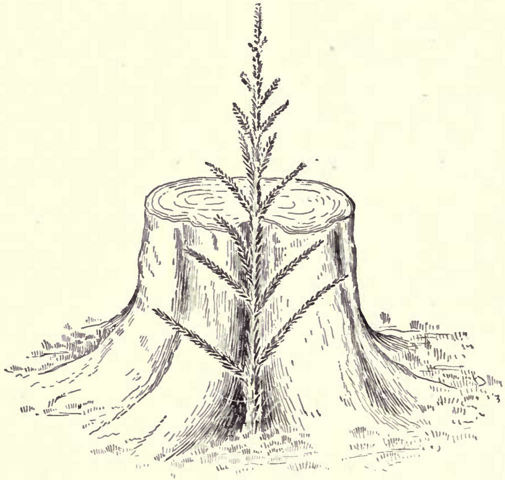

FIG. 48.—Seedlings are sometimes set close to stumps to protect them from the trampling of cattle.

cially is this the case where the trees are of the broad-leaved species, which are preferred by cattle. However, in the case of well-established forests in which there is no special desire for a renewal of growth, no great injury can come from moderate pasturing. Cattle are rigidly excluded from most European forests, but in some of the more remote districts, where timber is still quite cheap, it is customary to pasture forests. Of course,

where the range is large and not fully stocked, the injury is much less than where the range is crowded. This combination of forest and pasture has led to the use of several methods of protecting young seedlings against cattle, among the first of which might be mentioned the planting of seedling conifers between the buttresses of old stumps, where it would be very unlikely that the cattle would step on them. It is also practised to protect the seedlings by driving two strong stakes in the ground near them, and occasionally, over a considerable acreage, the cattle and deer may be fenced out until the trees are so large that they will not injure them. Under some conditions, the eating off of the leaves from the sides of the trunk of saplings would prove a desirable pruning. It is very certain that while forests and pastures cannot often be very well combined together, yet it is possible to combine them under some conditions. It is quite common to see the new growth of spruce and fir in European forests protected from the browsing of deer by covering the tips of the young shoots with a little coal tar or common cotton batting. The cotton batting seems to be very disagreeable to the deer, and to afford about as good protection as the coal tar. It is, however, rather more difficult to put on.

Severe Winters. These may injure many kinds of young seedlings, which when two or three years old will be perfectly hardy. Seedlings of such kinds should be dug at the end of the first season's growth and be heeled-in over winter, or protected where they grow by a mulch or earth covering in winter.

Alternate Freezing and Thawing. Seedlings are often thrown out of the ground by alternate freezing and thawing, and in this way have their roots broken. This is most likely to happen where the ground is bare; if covered with leaves or grass, or shaded in other ways, this seldom

happens. The best preventive is to mulch the surface soil with leaves or other similar material, but as mice generally like to live in such places, poison should be used. It should be placed under the mulch in tin cans laid on their sides, so they may be readily found in spring

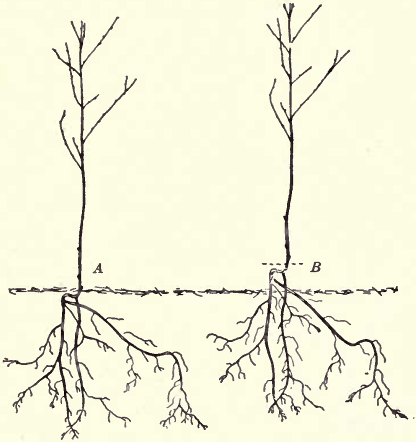

FIG. 49.—Heaving out by frost. *A*, Tree in natural position. *B*, Drawn up by alternate freezing and thawing.

and will not be liable to poison the birds. When seedlings are thrown out of the ground by frost, they should be pushed back and have the earth pressed against them as soon as the ground is thawed in the spring.

Late Spring Frosts are common in the low lands of many sections. They injure the trees by killing the new spring growth after it has started several inches. A large number of trees are seriously injured in this way, and are

classed as **frost tender trees,** and those that are not liable to this injury are termed **frost hardy trees.** Among conifers, the Spruces and Balsams are much injured by late spring frosts, while our Pines and the Tamarack, Red Cedar, and Arborvitæ are seldom if ever injured in this way. Deciduous trees recover from such injuries more quickly than Evergreens. Among the deciduous trees most liable to injury from this cause are the Ash, Mulberry, Oak, Maple, Basswood, Black Walnut, Butternut, and Box-elder, though they do not all suffer in the same degree. Among those that are not sensitive to late frosts are the Elm, Willow, Poplar, Birch, Hackberry, Wild Black Cherry, and Mountain Ash.

On account of this liability to injury from late frosts, it is customary to study the probability of damage from this cause in given locations, and to plant accordingly. It will often be found that in certain low spots there is greater liability to late frosts, while there is very little injury from this cause on the higher lands. It is customary among European foresters to protect young seedlings of some kinds, particularly Beech, from late frosts until they get up off the ground. For this purpose Birches twenty or more feet high are encouraged at intervals of thirty or forty feet, and the frost tender plants, such as Beech and Spruce, are set out between. The result of this arrangement is that the Birch, which is frost hardy, quite successfully protects the frost tender trees below it. After the frost tender trees are well off the ground, as ten or fifteen feet high, there is comparatively little danger from this source of injury, and the Birch is removed.

Sleet-Storms occasionally do much damage by breaking the limbs. Little can be done to relieve the trees, but preventive measures may be taken. If no large crotches are allowed to form in trees, and growth is kept

as near as possible to one central shaft, or the longer branches shortened so that they will not exert too great a leverage, the losses may be reduced to a minimum. Trees having brittle wood or weak crotches, as the Soft Maple, are much more liable to this injury than those with tough wood, as the Willows, Oaks, and Elms, and need more pruning on this account. Evergreens are likely to be broken by heavy snows that freeze on the leaves. This

FIG. 50.—Trees heavily loaded with ice after a sleet-storm.

may be prevented on lawn and shade trees by shaking the snow off from them before it freezes.

Frost-Cracks are a rather infrequent injury caused by the cracking of trees from centre to outside, due to uneven contraction in very cold weather. They are generally accompanied by a loud report. Such cracks are often eight or ten feet long, and occasionally longer. They generally close up again when the wood thaws out, and during the following summer grow over only to burst open again the next winter. This alternate bursting

open and growing over may continue for many years, until very conspicuous and peculiar wounds are formed. In such cracks, insects and rot-producing fungi find favorable lodging-places, and as a result trees are seriously injured, and are liable to decay in the trunk. There are no practical remedies for such injuries.

Wind. Injuries from wind are common where thinning is done to a great extent at one time about shallow-rooted trees, such as Spruce growing on moist soil. These injuries can be avoided only by thinning gradually. In many such cases, on timber lands, gradual thinning is impracticable, and it is then best to cut all the merchantable timber, for if left, it is sure to be blown down.

FIG. 51.—Old frost-cracks in Sugar Maple.

On our prairies, where the soil is light and easily moved by the wind, it is not uncommon to have young seedling trees seriously injured by the blowing away of the soil around the roots, which often leaves them uncovered for three or more inches. This injury usually takes place in the spring, and may be almost entirely prevented by seeding the land to oats about the middle of July, at the time of the last cultivation. Sown at this season the oats form a good sod that serves to hold the soil in place until spring, when it is easily broken up by cultivation, but even then the roots prevent the blowing away of the soil.

Occasional strips of grass are also a preventive of this injury, or mulching may be resorted to.

Snow Crust. The settling of a snow crust that has formed on the top of deep snowdrifts may cause injury to young trees by stripping off their branches and breaking the stems. It may be prevented by breaking up the crust or by thinly scattering over the snow some sand, ashes, or other material that will absorb the sun's heat and cause the crust to melt before the snow underneath melts. This injury seldom occurs except under drifts, and a little good judgment in selecting the location and arranging the windbreak so as to prevent drifts may obviate this source of injury.

Drought. Injuries from drought may be prevented to a great extent by constant cultivation, but where this cannot be done mulching is a good substitute. Attention to thinning at the proper time so as not to get the soil filled with roots will also help to prevent injury from drought. Willow windbreaks can be grown without any cultivation, after being once well established, in the driest portion of Minnesota, if they are kept mulched with straw or litter for six feet on each side. Mulching also prevents injury from severe freezing of the roots.

Sun-scald. Nearly all of our cultivated trees may be injured by sun-scald. This occurs, almost without exception, on the southwest side of unprotected trees of Hard and Soft Maple, Basswood, Box-elder, Black Walnut, etc. Oaks and all other trees are occasionally affected. It never occurs when the trees are sufficiently close together to shade their trunks, and for this reason the growth of shrubs and low branching trees should be encouraged on the south and west sides of groves where they do not crowd the principal kinds. Street trees liable to this injury may be protected by burlap sacking, straw, or other similar material. When injuries from sun-scald

occur, the loose bark should be cut off down to the live growth and the wood coated with paint, to prevent its seasoning, or the wound wrapped in cloth. Trees inclined to the northeast are most liable to sun-scald, be-

FIG. 52.—Trunk of Soft Maple badly sun-scalded.

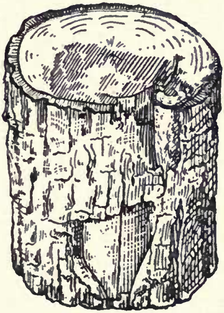

FIG. 53.—Section of trunk of sun-scalded Basswood, showing dead bark and amount of wood decayed. The top and roots of the tree from which this section was cut were perfectly healthy at the time when the trunk broke off at the sun-scald.

cause the rays of the sun strike the trunk more nearly perpendicular.

Broken Branches and Decay. Large wounds are sometimes formed by the breaking down of a branch, or by decay, which may have started in a wound made by pruning. In such cases the broken and decayed wood should be cleared away, and the exposed surfaces treated

with a very heavy coat of white-lead paint, grafting-wax, or other material that will keep out water and disease. If the wound is very large, or forms a hole in which water is likely to stand, it should be cleaned and pointed as recommended, and then covered with a sheet of zinc, carefully tacked on, and the joints closed with grafting-wax to keep out water.

Fungus Diseases are quite common sources of injury to trees of all kinds, including those of our forests. They attack the foliage, trunk, and roots. Occasionally very serious losses occur in timber trees from those that cause the trunks to rot. They are generally most numerous in sections where there is not much of a circulation of air. This subject is too large for a detailed account of any of them here, and only one is referred to, which, although not very common, is occasionally quite injurious. It is known as the toadstool root fungus, *Agaricus melleus*. This fungus lives upon the roots of Pines, Spruces, Firs, etc., and occasionally kills them. At one stage of its growth it lives on the decaying wood of Oaks and similar trees.

FOREST FIRES.

Forest Fires are the one great cause of injuries to forests in the United States. All other causes of injury are very slight in comparison to it, and could this one cause be removed it is more than probable that the natural renewal of our timber lands would be sufficient to maintain the timber industries of Minnesota for very many years to come.

Fires in this country have destroyed large areas of pine log timber before it could be made accessible to market. It is undoubtedly true that more pine timber has been destroyed by fire than the lumbermen have ever cut.

On account of this great danger to pine timber, and on account of high taxes, the lumbermen have been discouraged from holding their pine lands for a second growth, but prefer to cut every tree that can be made into salable lumber and then abandon the land. But even under such conditions, it occasionally happens that the land is not burned over, or only slightly burned, for

FIG. 54.—*Agaricus melleus*, a fungus that is occasionally very injurious to trees by destroying their roots. *A*, A fruiting portion of the fungus.

a number of years, when it will generally produce a good second cutting. Some land in Minnesota that was first cut in the early days of the logging industry, when it was customary to cut nothing but that which would make a ten-inch log, have been logged two or three times since, and with a good profit.

In Minnesota and Wisconsin fires render most of the cut-over lands entirely non-productive, and since the annual increase of the trees that should grow on such

land is at least 185 feet board measure per acre, it is plain that the loss to the people on the 10,000,000 or more acres of these cut-over lands is very large.

It is impossible for fires to run over any forest land without doing great injury. The amount of damage done by them is difficult to estimate, and varies much according to the time of year, the age and condition of the trees, the soil and the severity of the fire.

Forest fires are sometimes grouped into the three following classes: 1. **Underground Fires,** that do not show much on the surface, but which destroy the roots of trees and greatly injure the soil. 2. **Surface Fires,** which burn the leaves and grass in the woods, and do much damage by destroying the forest floor and killing the young seedlings. 3. **Crown Fires,** which run in the crowns of the trees, and when once started are almost irresistible. The latter is one of the worst forms, and is generally accompanied by surface, and often by underground, fires.

The Killing of Mature Trees by any of these three kinds of fires entails but a slight loss comparatively to the timber, providing it is accessible to market, as the trees can be cut the following winter. But fires that kill the mature growth generally do great damage by killing the young growth and destroying the forest floor. Timber that is allowed to stand more than one or two years after being killed by fire generally suffers much from insects and fungus diseases. This is most evident in the case of White Pine, Birch, Poplar, and similar soft woods, but even hard woods are injured by insects if allowed to stand long after being killed.

The Killing of Half-Grown Trees by forest fires causes a loss that amounts not only to the value of the timber trees, but to the value of the seeding and shading trees and the forest floor. The value of the trees alone

in this case is not a fair standard by which to measure the loss, since at this stage of their growth they are making their most rapid increase, and their value should be computed as the amount upon which the increase is paying a good interest. For instance, the Division of Forestry of the Minnesota Experiment Station found land that was well stocked with young White Pine (six inches in diameter and fifty feet high) that could be bought for about one dollar per acre, and yet the annual increase on the trees would pay five per cent on a valuation of $100.00 for the next twenty years. The reason why such a state of affairs exists is that there is such great danger from fire that the investment fails to command the money of careful investors.

The Destruction of the Forest Floor by fire greatly lessens the probability of an immediate renewal of valuable tree-growth upon the land, and therefore is one of the greatest injuries to forests. The value of the forest floor can hardly be estimated, but the expense that would be necessary after a severe fire to produce conditions as favorable to the seeding of our timber lands as those found in unburned forests would often be not less than twenty-five dollars per acre.

Light Fires, which repeatedly run over the ground, and which, by the casual observer are thought to be of no importance, often destroy the seeds in the surface soil and the young tree seedlings, besides injuring the forest floor, and unless such fires are prevented, it is impossible to secure a good growth of timber on any land. The fires that burn over the land shortly after it has been logged, and which feed on the tops and other waste parts of the trees, generally destroy a large number of young seedling trees, perhaps all of them, so that in order to secure a new growth seeds must be brought from a distance. Owing to the great heat developed by such fires in dry

weather, they are unusually destructive, and leave very little humus in the top soil. For some reason, land that has been burned over in this way is a long time in recovering from its injuries. Besides the injuries already cited, all forest fires kill or drive out much of the game in our forests.

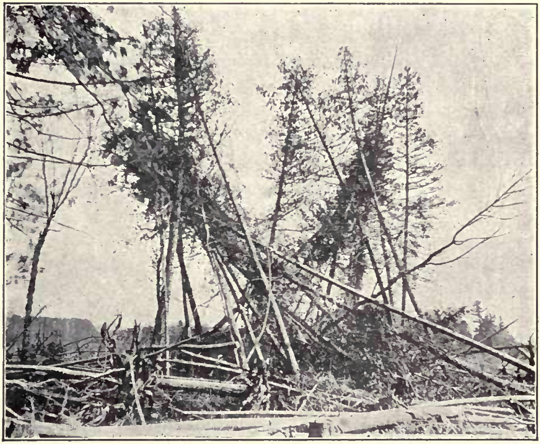

Fig. 55.—A Fire Fall. Roots burned off and trees blown down in great confusion.

Spring Fires are very injurious to trees, and especially tender seedlings, for trees in the spring of the year are full of sap, and can endure but little heat.

Summer and Autumn Fires generally run deep into the ground, and if the soil is very dry and of a peaty nature burn off the roots of the trees. The result of this is that the trees are blown down in great confusion, and form what are known as "fire falls." Where a thick growth

falls, it forms an almost impassable barrier, which remains in this state until decay and repeated fires, extending over a long series of years, finally destroy the trees, and perhaps get the land into condition for a new growth.

Causes of Forest Fires. The only natural causes of forest fires are friction and lightning, both of which occasionally start fires in dead trees, but as such fires are most likely to be set during a rain they seldom do much damage. Practically all the injurious forest fires that have devastated the forested part of this country have resulted indirectly either from a lack of appreciation of the damage done by them or from carelessness and ignorance. In the disastrous Hinckley fire of 1894, the damage was done by a large fire formed by the combination of several small fires that were allowed to smoulder in the swamps near Hinckley for a week or more, which, when fanned by a dry, hot wind, attained an irresistible energy. If there had been a fire law that could have been properly enforced at that time, or if the people near Hinckley had been aware of their danger, that great fire, with its attendant great loss of life and property, need not have occurred.

Fires Often Escape from Settlers when they are clearing land, and are sometimes started by them to make pasture for their stock. The careless use of fire by the hunters, prospectors, and others who camp in the forest and leave their camp-fires unextinguished is another common cause of fires. Railroads set many fires, and should be required to more rigidly conform to the law requiring them to use spark-arresters and to keep their right of way free from combustible material.

The moral effect of a properly enforced forest-fire law is not only very great in restraining the careless, but especially in educating law-abiding citizens in the idea that there is value in young seedlings and timber trees.

The Prevention of Forest Fires will be most certainly accomplished by educating our people to an appreciation of the amount of damage done by them. In some sections it is impossible to enforce the law against setting forest fires, owing to the belief that fires are a good thing for their sections in destroying tree-growth and bringing the land into condition to be easily taken up by settlers. There is some truth in this claim, but since the fires destroy all increase on the land they sweep over, a large amount of it is thereby rendered entirely unproductive long before settlers are ready for it, while in the meantime it might be producing a crop of valuable timber. Then again, it is the greatest injustice to allow one person to burn the property of another, which right is practically claimed by those who advocate the unrestricted use of fire.

With a Desire in the Minds of People to keep out forest fires, there are many precautions that could be taken that would lessen the chances of their starting, and when started would aid in controlling them. The first thing is a good fire law, such as now stands in Minnesota, which recognizes the fact that the State and county should protect forest property from fire for the same reason that a town or city protects the property of its citizens from fire. This law puts two-thirds the expense of enforcing it on the State and the other one-third on the county. The chief reasons why a part of this burden should be borne by the State and not by the counties alone are that fires spread from one county to another, and the State must be organized to extinguish such fires when they have once started, since it is the only competent authority that can do this. Then again, the State of Minnesota owns, or will own, when surveys have been completed, about 3,000,000 acres of land scattered through the forested area, besides possibly nearly as great an area that

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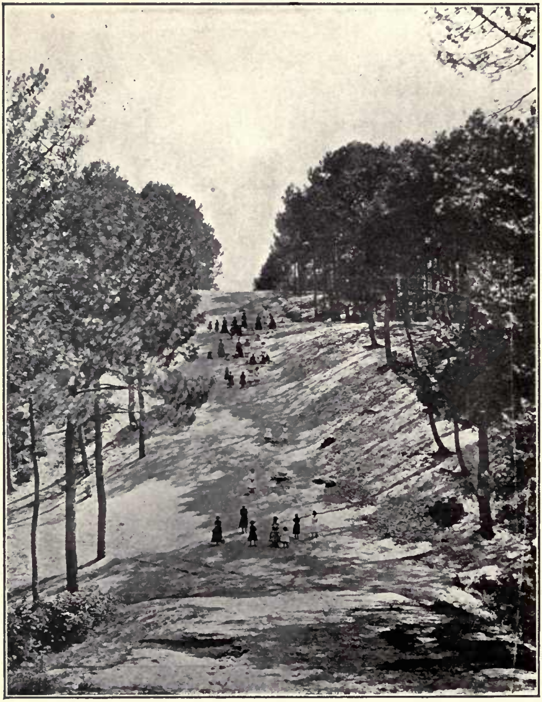

Fig. 56.—Firebreak on a great sand-dune in France, which has been successfully covered with Pine.

has been bid in by the State for delinquent taxes. A large part of the land the State owns has a valuable growth of trees on it, much of which is liable to injury or destruction by fire at any time, and the State can well afford to provide protection for it.

Firebreaks, in the shape of clean earth roads, ploughed strips, etc., are effective against ordinary forest fires. Very often by clearing up and widening the course of a brook, a very efficient firebreak may be made which will supplement other firebreaks. It is stated on good authority that fairly satisfactory and very cheap firebreaks may be made in rough stump land by fencing off a strip about three rods wide and pasturing it with sheep, which will kill out all the brush in the course of a year or two. The sheep do this most effectually if the land is rather overstocked, and they receive a little grain to make up for their lack of pasturage. Fig. 56 shows a firebreak or lane on Le Grande Dune in France.

The Burning of Trash left on the ground at the time of logging is recommended by some of our best woodmen as a means of doing away with one of the sources of our worst forest fires. This trash can be burned early in the spring, or at other times when the ground is wet and fire is not likely to get beyond control. On the other hand, it is well known that there are many seedlings on such land that would be seriously injured or destroyed by such treatment. It is also known that under the trash left after logging are generally found about the best conditions for pine seeds to start and for the seedlings to grow, so that some of our best authorities condemn the practice. It would seem, however, that on account of the great liability of fires starting in such trash, prudence would generally advocate the burning of it while it could be controlled, but this should be done so as to cause as little injury as possible to new growth, and especial care should

be taken to save seeding trees. The cost of such work has been urged against it, but this has often been overestimated, and it seems evident that it is entirely practicable.

The Methods of Fighting Surface Fires are various, and their use depends on the conditions under which the work must be done. Where possible, the ploughing of a firebreak a rod or more wide is most satisfactory, but this is seldom practicable within our wooded areas. **Back Firing** is generally the most successful method of making a firebreak. When this is to be practised, a convenient place to fight fire should be chosen, at some distance ahead of the main fire, where the back fire should be started, after every precaution has been taken to prevent its getting beyond control. Where a supply of water can be obtained, surface fires can be most easily put out by applying it through a common sprinkling-pot with a good rose sprinkler on it. This is especially effective where fire is running through grass, and those who have never tried it will generally be surprised at the effectiveness of this method. Where the fire is burning in several inches of dry leaves, a small strip should be cleaned of them before applying the water. Gunny sacks or similar material wet in water make very effective weapons with which to fight fire. Where the soil is sandy, sand is often the best material obtainable for putting out fires.

Underground Fires, such as occur in bogs and other soils containing a large amount of organic matter, when once started, are often very hard to subdue, owing to their great depth, and, where not looked after, sometimes burn for a year or more unless we have very heavy rains. They often cause great injury by burning out all organic matter from the soil and leaving it in poor shape for crops, though a rather severe but not excessive firing of bogs

may do much to clear the land of roots and put it in shape for a good hay meadow. Then, too, they often so reduce the level of the land by burning out the organic matter as to make it wet and of no value for agricultural crops. If such fires are attacked soon after they secure a foothold in the soil they are seldom very difficult to put out. Where not deep in the ground or of very great extent the burning peat may be dug out and watered, but this is often impracticable on account of the heat. In this latter case a ditch should be dug around the fire as close to it as practicable and of sufficient depth to reach standing water or the subsoil. The fire should then be carefully watched to see that it does not get beyond the ditch. It is seldom that sufficient water can be put on a large bog fire to put it out, on account of the great amount of water that dry peat will absorb and the protective covering of ashes and peat usually found over a bog fire.

NOTABLE FOREST FIRES.

Among the worst forest fires which have occurred on this continent are the following:

Miramichi Fire of 1825. This occurred near Newcastle, on the Miramichi River, in New Brunswick. In nine hours it had destroyed a belt of forest eighty miles long and twenty-five miles wide, and almost every living thing was killed on that amount of territory; even the fish were destroyed in the smaller lakes and streams. It is estimated that the loss from this fire, not including the value of the timber burned, was $300,000. One hundred and sixty persons lost their lives, and nearly 1,000 head of stock were killed.

The Peshtigo Fire occurred in October, 1871. This burned an area of over 2,000 square miles in Wisconsin. Between 1,100 and 1,500 persons lost their lives, and

property to the amount of many millions of dollars was destroyed.

Very serious fires have occurred in Michigan from time to time, in one of which, in about 1871, a strip of territory forty miles wide and 180 miles long, extending across the central part of the State from Lake Michigan to Lake Huron, was devastated. More than ten million dollars' worth of timber was burned, and several hundred persons perished.

The Hinckley Fire occurred Sept. 1, 1894, and was the most destructive fire of recent years. Hinckley, Minnesota, and several other towns were destroyed, about 500 lives were lost, and more than 2,000 persons were left destitute. It is estimated that the loss in property amounted to about $25,000,000. The loss of life from this fire would have been much more than stated had it not been for the fact that the railroad companies ran special trains to carry the settlers away from the flames. This fire was wholly unnecessary, and could easily have been put out in its earlier stages. For two weeks previous to the breaking out of this fire into an uncontrollable mass of flame, small fires had been raging in swamps about Hinckley, and filled the town with dense smoke, and it was only when these became united under the direction of a hot south wind that it passed beyond control. Had the present forest-fire law of Minnesota been in force at that time this fire would undoubtedly have been prevented.

Sand-Dunes. In places in various parts of this country, notably along portions of the seashore and along the shores of the Great Lakes, there are quite considerable sand-dunes. By this is meant the drifting sands which are easily blown about after the vegetation, which has held them in place, has been broken. Along the shore of New Jersey, at Seven Mile Beach, there is a dune which

is travelling inward at the rate of perhaps fifteen feet per year, and is destroying quite a growth of forest trees. This dune is thirty or forty feet high—as high as the trees—and as the prevailing strong winds are from the east, its tendency is always inland.

In some parts of Europe, notably in Gascony, France, dunes have destroyed an immense amount of territory in former ages. Whole villages have at times been gradually wiped out by the encroaching dunes. The sand is so fine and so easily moved by the wind that there is very little chance for any vegetation to grow on it, and it is

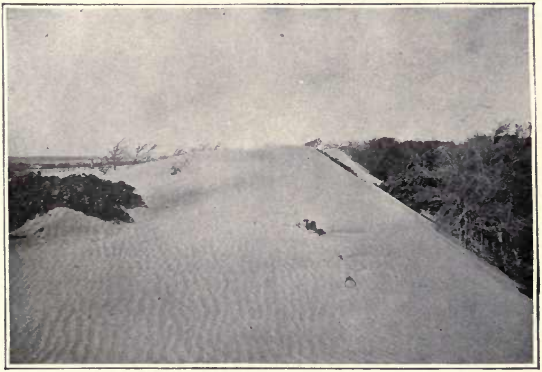

Fig. 57.—Sand-dune near Seven Mile Beach, New Jersey.

only in recent times that methods have been successfully adopted to hold it in place.

There are Notable Sand-Dunes at Provincetown on Cape Cod, Mass., on which the State and National governments have expended much money in efforts to hold them in place. These dunes are in three ridges with deep valleys between in which the humus of the ground cover of for-

mer forests may be seen and even old stumps as much as twelve feet high are occasionally uncovered by the movement of the sands, showing that formerly all this section was covered by forests.

After extensive trials with Maritime Pine, Scotch Broom (Genista), White Poplar, and Willows, all of which have failed to give satisfaction, it has been found that the native Bayberry (*Myrica cerifera*) is the most satisfactory of anything tried in the severest situations on these dunes. The Beach Grass is excellent for holding the sand for a few years, but dies out, and the most promising results have been obtained by planting Bayberry in with it. The native Pitch Pine has also proven desirable as a soil cover after the movement of the sand has been somewhat checked. The native trailing plant, *Hudsonia*, is also a most excellent sand-binder and comes in quickly when the sand is stable. In the case of these special sands, if the movement on the windward side is checked the leeward side soon becomes covered with vegetation.

The Most Improved Way of Checking Sand-Dunes that are Easily Moved by Wind is to first make a windbreak of boards, poles, or brush, which may be pulled up as the sand drifts up onto them. These are used temporarily to afford an opportunity of getting vegetable growth started. As a rule, the vegetable growth which has been most successfully used for fixing sand-dunes is that of plants that grow naturally in such places. Such species are generally those that grow out long creeping stems at or just below the surface of the ground, and also such as are capable of healthy growth even when half buried by encroaching sand. We have a number of native species that are adapted to this purpose on inland dunes, among which are the Sand Reed, the Sand Cherry, several varieties of Willows, and Quack Grass.

Where these once gain a foothold upon a sand-dune, they hold it better than would be possible by artificial means. In protecting such land it is generally best to dig up clumps of these grasses, or use long Willow cuttings, and set them in place in a wet time.

In some sections along the Great Lakes the sand is now held in place by the natural covering of weeds and shrubs, but should this be removed and the land broken up, there would be much trouble in getting it again fixed in place. Such is the case along the southern shore of Lake Michigan.

CHAPTER IX.

RATE OF INCREASE IN TIMBER.

The Rate of Increase on Timber Trees varies according to the kind and age of the trees and the conditions under which they are growing. Most of the Pine trees cut for log timber in the North have been upwards of 100 years old, and some of the White and Norway Pine that has been cut over 300 years old. Perhaps one of the largest White Pine trees ever cut in this country was scaled by H. B. Ayres. The tree was 253 years old, measured forty-eight inches in diameter on the stump, and yielded 4,050 feet board measure of log timber. The most rapidly grown trees recorded in Minnesota were: Norway Pine, 100 years old, thirty inches on the stump, yielding 1,050 feet board measure; White Pine, 106 years old, twenty-seven inches on the stump, yielding 1,050 feet board measure, and White Pine, 108 years old, thirty-two inches on the stump, yielding 1,450 board measure. The largest recorded acre yield of White Pine in Minnesota was near Carlton. The full yield of this acre was 111,050 feet board measure, and after deducting for rot and crooks 94,264 feet of sound timber remained. The average yield of White Pine is much below this and large areas have been cut that did not yield over 5,000 feet board measure per acre.

Marketable White and Norway Pine may be grown in about thirty years under the best conditions, and at this age will probably be about eight inches in diameter and

forty feet high. But such trees are then growing very fast, and as the approximate increase in volume of the tree is as the square of the proportionate increase in diameter and the waste in working greatly decreases with the size of the trees, the cutting of them at such an early age would be at a loss of future profits. Such trees have very little, if any, heart wood, and yet this kind of timber is being grown and marketed in many of the Eastern States. In fact, there is very little heart to any of the pine now cut in the New England States, as it is practically all young second growth, and is generally marketed about as soon as it attains sufficient size to be salable, without regard to the fact that it is then making its most rapid growth.

From careful observation, the Experiment Station of the University of Minnesota estimates that on land adapted to the White Pine, with a thick growth of this kind of trees eight inches in diameter, the annual increase should be about fifty cubic feet, or 500 feet board measure, per acre. In some cases this rate of increase has been more than doubled, but under ordinary good conditions not over one-third as much increase need be expected.

The Thickness of the Annual Rings on trees varies with the conditions under which the trees make their growth, and is therefore a good index to these conditions. Trees that are crowded so that they make a very rapid upward growth form very thin rings, and when this upward growth ceases owing to the removal or suppression of surrounding trees much thicker rings are formed. Trees that are grown in the open, produce throughout their lives thick annual rings, which vary in thickness according to varying climatic conditions. Those of the White Pine vary in thickness from one-sixteenth of an inch or less in trees that are severely crowded to one-third of an inch in open-grown trees in good soil. Willows some-

times have annual rings three-fourths of an inch wide, showing the diameter growth to have been one and a half inches per year.

The Life History of a Mature Tree in virgin forest may often be determined by a study of the annual rings, in connection with the environment of the tree. The Division of Forestry of the Minnesota Experiment Station

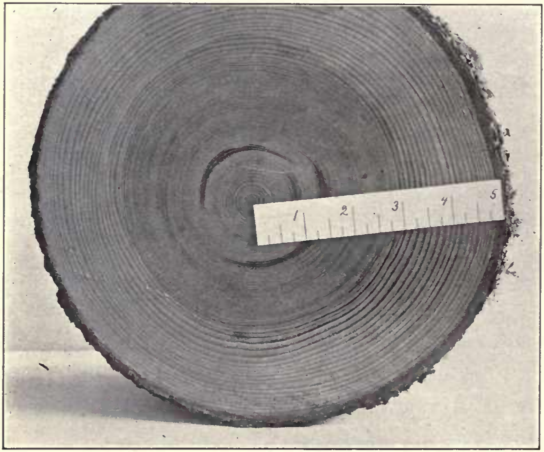

FIG. 58.—Cross-section of White Pine crowded and then open grown.

has made several studies of this kind, among which are the following:

Fig. 58 shows a section of a White Pine which made its growth under varying conditions. This tree started into growth under Birch and Aspen, and when from twenty to twenty-five years old was nearly suppressed by them. Overcoming them when thirty years old it

pushed rapidly upward until about its fiftieth year. It was then set free by fire, which checked its upward growth for about twenty-five years, when, owing to the crowding of surrounding trees, it began to again increase rapidly in height. When eighty-four years old fire killed the surrounding trees and set this one entirely free, in which condition it remained until it was cut eighteen years later. When cut it measured fifty-five feet high, thirteen inches through at the base, and contained 29.95 cubic feet of timber. During the last ten years it had made an average annual increase of 1.5 cubic feet.

This study brought out the following facts: 1. While rapid upward growth is being made the lateral accretions are slight. 2. Large accretions accompany full leafage. 3. After the surrounding growth is killed, the tree begins to strengthen the portion which receives the greatest strain by wind, that is, the lower part of the trunk. 4. In approaching the top of the tree the accretions are found to diminish as each live branch is passed.

Fig. 59 shows a section of a White Pine that was entirely open grown. This tree was cut when fifty-six years old, and measured eighteen inches in diameter on the stump, eight inches at twenty-five feet above the stump, and forty-eight feet in height. The volume of the stem when cut was 28.85 cubic feet; the accretion during the last ten years was 12.52 feet, which is equivalent to mean annual increment of 1.25 feet.

As the live branches of this tree occupied the whole trunk, the timber was very knotty. A proper crowding would have kept it from forming large branches on the lower trunk, stimulated its upward growth, and prevented so large an increment during the early life of the tree. But if, as with the former tree, it had been first crowded and then set free, the best timber in the least time would have been secured.

The Profit from an Investment in Land that is stocked with only very small coniferous seedlings is altogether too small and too remote to prove an attraction to investors at present, even were the danger from fire entirely eliminated. But there is considerable land that is now stocked with a good growth of young pine of fair size that could be bought and managed at a good profit

FIG. 59.—Cross-section of White Pine open grown.

if the danger from fire could be greatly reduced. This land in many cases would not have to be held more than ten or fifteen years to secure a good profit on the investment, after which the profit might be made nearly continuous. The rapid-growing deciduous trees, such as the Poplar, Willow, White and Yellow Birch, Soft Maple, Chestnut, Ash, Red and White Elm, Hackberry, Catalpa, Basswood, Locust, Black Walnut, and Tamarack, may sometimes be planted and grown at a profit on waste

land that is adapted to them, and should there be a stock of young trees of these kinds already on the land it can perhaps be soon made to yield a revenue in the shape of posts and fuel, and later of timber. Even the slower-growing deciduous trees, such as the Red, White, and Bur Oak, Hard Maple, and Rock Elm, increase very rapidly in good soil, and could often be made to yield a good profit if properly managed. However, most of the hard-wood lands of this section are of such good quality that they seem destined to be generally cleared for agriculture instead of being kept for timber.

Willow for Fuel. From a number of careful estimates it seems quite probable that good soil planted in White Willow will produce at the rate of from four to six cords of fire-wood per acre per year. If, then, ten acres were taken for this purpose, and one acre cut over clean each year, such amount of land would yield about fifty cords of fuel per annum, worth probably from two dollars to three dollars per cord in our prairie sections.

In starting such a wood-lot it would be desirable to set the cuttings two feet apart in rows eight feet apart, since at this distance, if cultivated, they will soon cover the land, and until the land is fully shaded cultivation seems to be necessary in order to keep down the weeds and to protect from drought. After the land is well shaded no further cultivation will be necessary.

At the end of five or six years some thinning should be done on all the land, and in this thinning probably at least half the trees should be removed. The remainder will soon fill up the vacancies, and in the course of three or four years more it should be again thinned out, and this should be repeated as often as they crowd one another until the trees on the land remain about twelve feet apart each way, after which the land should be treated as coppice, and since this tree renews itself very quickly

and vigorously from sprouts, and continues to do so for a long period of years, it is probable that such a plantation will last indefinitely.

Willow wood makes good summer fuel, and as a fence-post, when the bark is removed and the wood well cured, it is quite satisfactory, and will last in the soil about seven years. It is also good for poles when peeled and dried.

The Common Cottonwood on very rich soil will probably yield from five to seven cords of firewood per acre per year.

DIAMETER GROWTH OF SOME MINNESOTA TREES.

Cottonwood	1 inch in 1.4 years
Norway Spruce	1 inch in 2.5 years
Silver Maple	1 inch in 2.7 years
White Willow	1 inch in 2.8 years
Basswood	1 inch in 4.5 years
Sugar Maple	1 inch in 6.6 years
White Elm	1 inch in 6.8 years
Bur Oak	1 inch in 8.5 years

The height growth of Silver Maple and White Willow is about two feet per year, Norway Spruce one foot per year. Bur Oak averaging thirty feet in height makes an average growth of about .55 foot per year, while the rate of height growth of the first twenty feet of marketable cordwood is about one foot in 1.5 years. The height growth of Cottonwood varies from two to eight feet per year. A fifteen-year-old Cottonwood will often grow in height three feet per year. Black Spruce has shown a diameter growth of one inch in 14.7 years, and a height growth of one foot in 2.3 years.

CHAPTER X.

FOREST MENSURATION.

MEASUREMENT OF SINGLE TREES.

Trees which are to be Cut May be Considered in Two Classes, in the first of which comes all those which contain timber material, and in the second those which are too small to be of value for timber. The material of the first class is in the main part available for timber, and in part for firewood, while the stump, smaller limbs, and leaves are waste; the material of the second class may be used in part for firewood, fence-posts, etc. For timber purposes, the cubic contents of the wood only is considered, while for firewood the bark is included in the calculation, so that we may measure part of the tree without bark and part with bark on. For timber, usually only the main portion of the trunk is considered, especially in coniferous woods, but for firewood all limbs that will make a stick of cordwood must be included. In this discussion we will consider only the trunks of trees, as the volume of the limbs must be determined separately, but in the same way.

The Volume of a Standing Tree can be gotten at only roughly, as there is no geometric figure which exactly represents the shape of the trunk, the latter varying much under different conditions of growth. The volume of a paraboloid, the geometric figure which approaches nearest to the form of a tree, is equal to the product of the basal cross-sectional area by one-half the height. The

basal area of a tree is taken at breast-height, to avoid the excessive swelling near the ground. Breast-height is usually considered as four feet six inches above the ground, at which point the diameter is measured by a pair of calipers in inches, and the area in square feet of the corresponding circle is found in a prepared table of such areas. The height of the tree may be determined by triangulation, in which various instruments are used, as the transit, the altimeter, or a mirror hypsometer. A

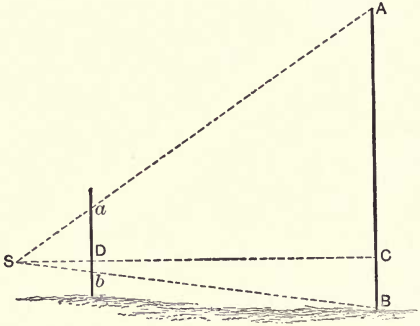

FIG. 60.—Diagram showing method of measuring the height of a tree by a simple geometrical method.

simple geometrical method is illustrated in the figure. A measuring-rod is set up at a convenient distance from the tree AB, the eye of the observer is at S, and the lines of sight to the top and bottom of the tree intersect the rod at a and b. Then, by measuring the distances from the observer to the rod and to the tree the height is given by the formula $H = \frac{ab \times SC}{SD}$.

Now, considering the tree as a paraboloid, its basal area times one-half the height will give approximately

the volume. For example: A White Pine has a diameter at breast-height of 18.7 inches, and the height of the tree is eighty-four feet; what is the volume? By reference to the table of areas of circles the area corresponding to a diameter of 18.7 inches is found to be 1.9072 square feet. Multiplying this by one-half the height, the approximate volume of the tree is found—$1.9072 \times 42 = 80.1024$ cubic feet.

The Volume of a Standing Tree may be Obtained by Employing a Form Factor which has been previously determined for that particular species by the felling and accurate measurement of a great many sample trees of approximately the same dimensions and grown under the same conditions. The form factor is expressed as a decimal, and is the ratio of the mean volume of the

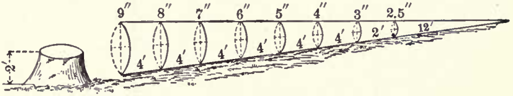

FIG. 61.—Diagram illustrating method of determining the volume of a felled tree.

sample trees to the volume of a cylinder with the same diameter as the diameter of the mean sample tree at breast-height, and whose length is equal to the height of the tree. For example: A Tamarack measures 6.9 inches in diameter, breast-high, and the height of the tree is fifty-one feet. Its volume by accurate measurement of the felled tree is 7.21 cubic feet, and the volume of a cylinder with a diameter of 6.9 inches and a length of fifty-one feet is 13.24 cubic feet. The form factor or factor of shape is therefore $7.21 \div 13.24 = .54$, and if this Tamarack represents the mean of a large number of trees of approximately the same dimensions, the factor may be applied to all of them, or to all trees of the same size and grown under the same

conditions. In the same way factors are determined for all sizes and tabulated for future use. In application, the volume of a tree 6.9 inches in diameter, breast-high, and fifty-one feet high, would be found thus: Volume of cylinder × form factor equals volume of tree, or 13.24 × .54 × 7.21. This method gives a much closer approximation than could be obtained by using a geometric figure supposed to represent the shape of the tree.

The Volume of a Felled Tree may be determined more accurately. It is considered in sections, or log lengths, and the volume of each section is found by multiplying the middle cross-sectional area by the length. The degree of accuracy of this method depends on the length of the sections; the shorter they are the more accurate the result. The last section at the top, when small, may be treated as a cone whose volume is equal to the basal area times one-third its length; or when large and tapering off suddenly it may be considered as a paraboloid whose volume is equal to the basal area times one-half its length. The sum of the volumes of all the sections will be the volume of the tree-trunk.

For example: A tree is felled at two feet above ground and calipered at the stump and every four feet along the trunk down to three inches in diameter, and also at two feet above the last measurement. The remaining distance to the top of the tree is twelve feet. (See Fig. 61.)

By reference to the table of areas of circles on page 171, the areas at each point calipered are found:

Area at diameter of 9 inches	.4418
Area at diameter of 8 inches	.3491
Area at diameter of 7 inches	.2673
Area at diameter of 6 inches	.1963
Area at diameter of 5 inches	.1364
Area at diameter of 4 inches	.0873
Area at diameter of 3 inches	.0491
Sum of areas	1.5273

AREAS OF CIRCLES.

Diameter, Inches.	Area, Square Ft.	Diameter, Inches.	Area, Square Ft.	Diameter, Inches.	Area, Square Ft.	Diameter, Inches.	Area, Square Ft.	Diameter, Inches.	Area, Square Ft.	Diameter, Inches.	Area, Square Ft.
0.0	0.0000	5.7	0.1772	11.4	0.7089	17.1	1.5949	22.8	2.8352	28.5	4.4301
0.1	0.0001	5.8	0.1835	11.5	0.7214	17.2	1.6136	22.9	2.8602	28.6	4.4612
0.2	0.0002	5.9	0.1899	11.6	0.7340	17.3	1.6324	23.0	2.8852	28.7	4.4925
0.3	0.0005	6.0	0.1963	11.7	0.7467	17.4	1.6513	23.1	2.9103	28.8	4.5238
0.4	0.0009	6.1	0.2029	11.8	0.7595	17.5	1.6703	23.2	2.9356	28.9	4.5553
0.5	0.0014	6.2	0.2096	11.9	0.7724	17.6	1.6894	23.3	2.9610	29.0	4.5869
0.6	0.0020	6.3	0.2164	12.0	0.7854	17.7	1.7087	23.4	2.9864	29.1	4.6186
0.7	0.0027	6.4	0.2234	12.1	0.7986	17.8	1.7280	23.5	3.0120	29.2	4.6504
0.8	0.0035	6.5	0.2304	12.2	0.8118	17.9	1.7475	23.6	3.0377	29.3	4.6823
0.9	0.0044	6.6	0.2376	12.3	0.8252	18.0	1.7671	23.7	3.0635	29.4	4.7143
1.0	0.0055	6.7	0.2448	12.4	0.8387	18.1	1.7868	23.8	3.0894	29.5	4.7464
1.1	0.0067	6.8	0.2522	12.5	0.8523	18.2	1.8066	23.9	3.1154	29.6	4.7787
1.2	0.0079	6.9	0.2597	12.6	0.8660	18.3	1.8265	24.0	3.1416	29.7	4.8110
1.3	0.0092	7.0	0.2673	12.7	0.8798	18.4	1.8465	24.1	3.1679	29.8	4.8435
1.4	0.0107	7.1	0.2750	12.8	0.8937	18.5	1.8666	24.2	3.1942	29.9	4.8760
1.5	0.0123	7.2	0.2828	12.9	0.9077	18.6	1.8869	24.3	3.2207	30.0	4.9087
1.6	0.0140	7.3	0.2907	13.0	0.9218	18.7	1.9072	24.4	3.2471	30.1	4.9415
1.7	0.0158	7.4	0.2987	13.1	0.9360	18.8	1.9277	24.5	3.2748	30.2	4.9744
1.8	0.0177	7.5	0.3068	13.2	0.9504	18.9	1.9482	24.6	3.3006	30.3	5.0074
1.9	0.0197	7.6	0.3151	13.3	0.9684	19.0	1.9689	24.7	3.3275	30.4	5.0405
2.0	0.0218	7.7	0.3234	13.4	0.9794	19.1	1.9897	24.8	3.3545	30.5	5.0737
2.1	0.0240	7.8	0.3319	13.5	0.9941	19.2	2.0206	24.9	3.3816	30.6	5.1071
2.2	0.0264	7.9	0.3404	13.6	1.0089	19.3	2.0316	25.0	3.4088	30.7	5.1405
2.3	0.0289	8.0	0.3491	13.7	1.0237	19.4	2.0527	25.1	3.4361	30.8	5.1740
2.4	0.0314	8.1	0.3579	13.8	1.0387	19.5	2.0739	25.2	3.4636	30.9	5.2077
2.5	0.0341	8.2	0.3668	13.9	1.0538	19.6	2.0952	25.3	3.4911	31	5.2414
2.6	0.0369	8.3	0.3758	14.0	1.0690	19.7	2.1167	25.4	3.5188	32	5.5851
2.7	0.0398	8.4	0.3849	14.1	1.0843	19.8	2.1382	25.5	3.5465	33	5.9396
2.8	0.0428	8.5	0.3941	14.2	1.0997	19.9	2.1599	25.6	3.5744	34	6.3050
2.9	0.0459	8.6	0.4034	14.3	1.1153	20.0	2.1817	25.7	3.6024	35	6.6813
3.0	0.0491	8.7	0.4129	14.4	1.1309	20.1	2.2036	25.8	3.6305	36	7.0686
3.1	0.0524	8.8	0.4224	14.5	1.1467	20.2	2.2256	25.9	3.6587	37	7.4667
3.2	0.0559	8.9	0.4321	14.6	1.1626	20.3	2.2477	26.0	3.6870	38	7.8758
3.3	0.0594	9.0	0.4418	14.7	1.1785	20.4	2.2699	26.1	3.7154	39	8.2958
3.4	0.0631	9.1	0.4517	14.8	1.1946	20.5	2.2922	26.2	3.7439	40	8.7266
3.5	0.0668	9.2	0.4617	14.9	1.2108	20.6	2.3146	26.3	3.7725	41	9.1684
3.6	0.0707	9.3	0.4718	15.0	1.2272	20.7	2.3371	26.4	3.8013	42	9.6211
3.7	0.0747	9.4	0.4820	15.1	1.2437	20.8	2.3597	26.5	3.8301	43	10.0847
3.8	0.0788	9.5	0.4923	15.2	1.2602	20.9	2.3825	26.6	3.8591	44	10.5592
3.9	0.0830	9.6	0.5027	15.3	1.2768	21.0	2.4053	26.7	3.8882	45	11.0447
4.0	0.0873	9.7	0.5132	15.4	1.2936	21.1	2.4283	26.8	3.9174	46	11.5410
4.1	0.0917	9.8	0.5238	15.5	1.3104	21.2	2.4514	26.9	3.9467	47	12.0482
4.2	0.0962	9.9	0.5345	15.6	1.3274	21.3	2.4745	27.0	3.9761	48	12.5664
4.3	0.1008	10.0	0.5454	15.7	1.3444	21.4	2.4978	27.1	4.0056	49	13.0954
4.4	0.1056	10.1	0.5564	15.8	1.3616	21.5	2.5212	27.2	4.0353	50	13.6354
4.5	0.1105	10.2	0.5675	15.9	1.3789	21.6	2.5447	27.3	4.0650	51	14.1863
4.6	0.1154	10.3	0.5787	16.0	1.3963	21.7	2.5684	27.4	4.0948	52	14.7480
4.7	0.1205	10.4	0.5900	16.1	1.4138	21.8	2.5921	27.5	4.1248	53	15.3207
4.8	0.1257	10.5	0.6014	16.2	1.4314	21.9	2.6159	27.6	4.1548	54	15.9043
4.9	0.1310	10.6	0.6129	16.3	1.4492	22.0	2.6398	27.7	4.1850	55	16.4988
5.0	0.1364	10.7	0.6245	16.4	1.4670	22.1	2.6638	27.8	4.2152	56	17.1042
5.1	0.1418	10.8	0.6362	16.5	1.4849	22.2	2.6880	27.9	4.2456	57	17.7206
5.2	0.1474	10.9	0.6481	16.6	1.5030	22.3	2.7122	28.0	4.2761	58	18.3478
5.3	0.1532	11.0	0.6600	16.7	1.5212	22.4	2.7366	28.1	4.3067	59	18.9859
5.4	0.1590	11.1	0.6721	16.8	1.5394	22.5	2.7611	28.2	4.3374	60	19.6350
5.5	0.1650	11.2	0.6842	16.9	1.5578	22.6	2.7857	28.3	4.3681		
5.6	0.1710	11.3	0.6965	17.0	1.5763	22.7	2.8104	28.4	4.3991		

TABLE SHOWING COMPOUND INTEREST ON ONE DOLLAR FOR ANY NUMBER OF YEARS UNTIL THE INTEREST EQUALS THE PRINCIPAL.

Yrs.	2%	Yrs.	2½%	Yrs.	3%	Yrs.	3½%	Yrs.	4%	Yrs.	4½%
1	.0200	1	.0250	1	.0300	1	.0350	1	.0400	1	.0450
2	.0404	2	.0506	2	.0609	2	.0712	2	.0816	2	.0920
3	.0612	3	.0768	3	.0927	3	.1087	3	.1248	3	.1411
4	.0824	4	.1038	4	.1255	4	.1475	4	.1698	4	.1925
5	.1040	5	.1314	5	.1592	5	.1876	5	.2166	5	.2461
6	.1261	6	.1596	6	.1940	6	.2292	6	.2653	6	.3022
7	.1486	7	.1886	7	.2298	7	.2722	7	.3159	7	.3608
8	.1716	8	.2184	8	.2667	8	.3168	8	.3685	8	.4221
9	.1950	9	.2488	9	.3047	9	.3628	9	.4233	9	.4860
10	.2189	10	.2800	10	.3439	10	.4105	10	.4802	10	.5529
11	.2433	11	.3120	11	.3842	11	.4599	11	.5394	11	.6228
12	.2682	12	.3448	12	.4257	12	.5110	12	.6010	12	.6958
13	.2936	13	.3785	13	.4685	13	.5639	13	.6650	13	.7721
14	.3194	14	.4129	14	.5125	14	.6186	14	.7316	14	.8519
15	.3458	15	.4482	15	.5579	15	.6753	15	.8009	15	.9352
16	.3727	16	.4845	16	.6047	16	.7339	16	.8729	and	271 dys
17	.4002	17	.5216	17	.6528	17	.7946	17	.9479	Yrs	9%
18	.4282	18	.5596	18	.7024	18	.8574	and	244 dys	1	.0900
19	.4568	19	.5986	19	.7535	19	.9225	Yrs	8%	2	.1881
20	.4859	20	.6386	20	.8061	20	.9897	1	.0800	3	.2950
21	.5156	21	.6795	21	.8602	and	54 dys	2	.1664	4	.4115
22	.5459	22	.7215	22	.9161	Yrs	7%	3	.2597	5	.5386
23	.5768	23	.7646	23	.9735	1	.0700	4	.3604	6	.6771
24	.6084	24	.8087	and	163dys	2	.1449	5	.4693	7	.8280
25	.6406	25	.8539	Yrs	6%	3	.2250	6	.5868	8	.9925
26	.6734	26	.9002	1	.0600	4	.3107	7	.7138	and	15 dys
27	.7068	27	.9478	2	.1236	5	.4025	8	.8509	Yrs	10%
28	.7410	28	.9964	3	.1910	6	.5007	9	.9990	1	.1000
29	.7758	and	26 dys	4	.2624	7	.6057	and	2 dys	2	.2100
30	.8113	Yrs	5%	5	.3382	8	.7181			3	.3310
31	.8475	1	.0500	6	.4185	9	.8384			4	.4641
32	.8845	2	.1025	7	.5036	10	.9671			5	.6105
33	.9222	3	.1576	8	.5938	and	87 dys			6	.7715
34	.9606	4	.2155	9	.6894					7	.9487
35	.9998	5	.2762	10	.7908					and	95 dys
and	1 day	6	.3400	11	.8982						
		7	.4071	and	326dys						
		8	.4774								
		9	.5513								
		10	.6288								
		11	.7103								
		12	.7958								
		13	.8856								
		14	.9799								
		and	74 dys								

The Use of the Compound-interest Table.

The compound interest given in the table is on one dollar, and is always cents, mills, etc., so the principal must be multiplied by it and the product pointed off as in any multiplication involving decimals.

Example: $450 at 3%. 16 years = 450 × .6047 = $272.12, the compound interest; then $450 + $272.12 = $722.12, the amount at compound interest.

It will be noticed that these areas are taken at the middle of a four-foot section; so multiplying the sum by four, the volume of the trunk, from the ground to a height of 28 feet, is found to be 6.1092 cubic feet. Treating the top length of twelve feet as a cone, its volume is one-third times the basal area into the height—$.0341 \times 12 \div 3 =$ .1364 cubic feet—which added to the volume of the lower portion gives total volume of the tree 6.2456 cubic feet.

MEASUREMENT OF GROWING STOCK.

The Growing Stock of a Forest, or Volume of Standing Timber, is equal to the sum of the volumes of all the trees. Where the tract is small caliper all the trees, or if the tract is large caliper all the trees on a small sample area selected as typical of the whole. If each species is in uniform stand, separation into species classes will be sufficient, but where much difference exists between individuals of the same species, due to conditions of growth, diameter, and height, classes in each species should be formed, and the volume of each class computed by itself. From the diameters obtained by calipering at breast-height the average basal area is determined in each class, and trees of corresponding diameters in each class are felled and measured accurately. The volume of a sample tree, or the mean volume of several sample trees, times the number of trees, gives the volume of that class, and the sum of the volumes of the different classes is the total volume of timber on the tract. The more sample trees that are measured, the more accurate will be the results, as trees vary so much in shape that quite different volumes may be obtained for two trees of the same diameter and height. The following example illustrates this method;

A Sample Acre of Jack Pine Shows the Following Stand:

Diameter, Breast-Height.	No. Trees.	Basal Area.
2 inches	1	.0218
3 inches	6	.2946
4 inches	6	.5238
5 inches	16	2.1824
6 inches	33	6.4779
7 inches	40	10.6920
8 inches	60	20.9460
9 inches	56	24.7408
10 inches	46	25.0884
11 inches	29	29.1400
12 inches	11	8.6394
13 inches	9	8.2962
14 inches	2	2.1380
15 inches	2	2.4544
	317	141.6357

Putting all these trees in one class, and dividing the total basal area by the number of trees, the mean basal area is found to be .4468, which would correspond to a diameter, at breast-height, of nine inches. Selecting a tree nine inches in diameter, it is felled and measured accurately, and the volume found to be 11.63 cubic feet. This volume of the sample tree is multiplied by the number of trees, 317, for the total volume on the acre —3,686.71 cubic feet. Greater accuracy may be attained by taking a sample tree for each diameter size, and a forest may be measured in miniature by felling and measuring a proportionate number of each diameter, say one per cent. of each.

The volume of a sample tree, or of sample trees, is often found by applying the factor of shape, which has been previously determined for that particular species and locality.

The Conversion of Cubic Feet Total Volume of Standing Timber into Feet Board Measure may be done roughly

by considering 1,000 cubic feet as the equivalent of from 4,000 to 7,000 feet board measure, according to the size of the trees, young growths giving much less than old growths.

The Conversion of Cubic Feet Firewood into Cords is accomplished by the use of the factors which experience has shown to be practically accurate. A cord of wood piled up occupies 128 cubic feet of space, but on account of the shape of the sticks much of this is air space, and the actual wood content much less than 128 cubic feet. In Germany a cord has been found to contain 83.2 cubic feet of wood. In Saxony, Dr. Schenck says that eighty-six cubic feet make a cord of ordinary firewood, and that 25.73 cubic feet of branch stuff will pile up to a cord. At the Minnesota Experiment Station by actual measurement of round, straight sticks, a cord has been found to contain as high as 102 cubic feet. This factor of 102 cubic feet may apply very well to straight, well-trimmed spruce, tamarack, etc., free from knots and limbs, but will be too high for Oak and similar wood, which is inclined to be more crooked, and does not pile so closely. A cord of small oak averaging 3.4 inches in diameter and ranging from 1.5 to 7.5 inches, consisting of 274 four-foot sticks, measured 69.67 cubic feet. Averaging these two extremes, 85.85 cubic feet is found in a cord of mixed wood, corresponding very nearly to the figure given by Dr. Schenck.

RATE OF GROWTH.

The Accretion of a Tree is the Increase in Wood Content as the Result of its Activity During the Growing Periods. The rate of growth is indicated by the increase in diameter, in height, or in mass, and may be considered as annual or as periodic. The diameter accretion is equal to twice the thickness of the annual rings for the

desired period, measured on the average radius. The current annual increase in diameter is taken as the average of several years back, as five or ten years. It is determined by counting off the required number of rings from the bark in and measuring their thickness. Twice that thickness divided by the number of years in the period will give the current annual diameter increase.

The Height Accretion is Determined by counting and measuring the annual cones which appear in a longitudinal section, or by measuring the length of log between two cross-sections which was grown in the time indicated by the difference in the number of annual rings at the two sections.

For example: A log is fourteen feet long. The lower end shows 178 annual rings and the upper end 150 annual rings. The difference in the number of these rings is 28, or twenty-eight years were required to grow the fourteen feet in length between the two cuts. The number of annual rings at any cross-section indicate the lifetime of that portion of the tree above the section.

Mass Accretion is the Increase in Volume of the Growing Tree. The volume increase of standing trees can only be arrived at approximately, and is based on the measurement of the volumes of trees of different ages; the difference will be the increase for the period. The increase in volume is often calculated as simple interest, but where the mass of the tree is considered as capital, interest is computed as compound.

The Rate of Mass Accretion of a Standing Tree May be Determined in the following manner: In mature trees the height growth per year is inconsiderable, and may be disregarded for short periods of time. The present and past volumes, then, vary as their respective basal areas. Taking twice the width of the rings for the period desired from the present diameter will give ap-

proximately the former diameter of the tree. From this diameter obtain the area at that time and compute percentage of growth from the difference between that and the present area.

For example: By cutting into the trunk of a tree, or by removing a core of wood with an accretion borer, and measuring the thickness of the annual rings for ten years, we find it to be .5 inch, and the present diameter of the tree inside bark is twenty inches.

Increase in diameter for ten years............	$.5\times 2=1$ inch
Diameter of tree ten years ago................	$20-1=19$ inches
Present cross-sectional area with diameter 20 inches..............................	2.1817 square feet
Area ten years ago, with diameter 19 inches....	1.9689 square feet
Increase in area for ten years............	.2128 square foot
Per cent. increase................	$.2128\times 100\div 10\times 1.9689=1\%$

The Determination of the Rate of Mass Accretion of a Standing Tree with compound interest is a more difficult matter, but Pressler, an eminent German forester, calculated tables for average thrifty trees and for very thrifty trees, the use of which renders the work of computation very simple. The width of rings for the desired period is measured and the diameter divided by twice the width of these rings. This gives relative diameter, opposite which, in Pressler's table (see page 178) will be found a number which is to be divided by the number of years in the period. The result will be the per cent. of accretion with compound interest. For example: A Cottonwood sixteen inches in diameter shows a growth of 2.2 inches on the radius for the last ten years. The diameter increase would then be 4.4 inches, and by dividing the diameter by the diameter increase, 3.6 is found to be the relative diameter. In Pressler's tables, opposite 3.6 is found

the number 81 in the column of average thrifty trees. Divide 81 by 10 (the number of years) and obtain the rate of increase with compound interest, 8.1 per cent.

PRESSLER'S TABLE.

Relative Diameter.	Average Thrifty Tree.	Very Thrifty Tree.	Relative Diameter.	Average Thrifty Tree.	Very Thrifty Tree.	Relative Diameter.	Average Thrifty Tree.	Very Thrifty Tree.	Relative Diameter.	Average Thrifty Tree.	Very Thrifty Tree.	Relative Diameter.	Average Thrifty Tree.	Very Thrifty Tree.
2.0	144	156	5.9	49	54	9.7	29	32	18.5	15	17	39	6.9	7.8
2.1	138	150	6.0	48	53	9.8	29	32	19.0	14	16	40	6.8	7.6
2.2	132	144	6.1	47	53	9.9	28	32	19.5	14	16	41	6.6	7.4
2.3	127	139	6.2	46	52	10.0	28	31	20.0	14	15	42	6.4	7.2
2.4	122	134	6.3	45	51	10.2	27	31	20.5	13	15	43	6.3	7.1
2.5	117	129	6.4	45	50	10.4	27	30	21.0	13	15	44	6.1	6.9
2.6	113	124	6.5	44	49	10.6	26	30	21.5	13	14	45	6.0	6.7
2.7	109	120	6.6	43	48	10.8	26	29	22.0	12	14	46	5.9	6.6
2.8	105	116	6.7	42	48	11.0	25	28	22.5	12	14	47	5.8	6.5
2.9	101	112	6.8	42	47	11.2	25	28	23.0	12	13	48	5.6	6.3
3.0	98	109	6.9	41	46	11.4	24	27	23.5	12	13	50	5.4	6.1
3.1	95	105	7.0	40	45	11.6	24	27	24.0	11	13	52	5.2	5.9
3.2	92	102	7.1	40	45	11.8	23	26	24.5	11	12	54	5.1	5.7
3.3	89	99	7.2	39	44	12.0	23	26	25.0	11	12	56	4.9	5.5
3.4	86	96	7.3	39	44	12.2	23	26	25.5	11	12	58	4.7	5.3
3.5	84	93	7.4	38	43	12.4	22	25	26.0	10	12	60	4.5	5.1
3.6	81	91	7.5	38	42	12.6	22	25	26.5	10	12	62	4.4	4.9
3.7	79	88	7.6	37	42	12.8	22	24	27.0	10	11	64	4.2	4.7
3.8	77	86	7.7	37	41	13.0	21	24	27.5	9.9	11	66	4.1	4.6
3.9	75	84	7.8	36	41	13.2	21	24	28.0	9.7	11	68	3.9	4.4
4.0	73	81	7.9	36	40	13.4	21	23	28.5	9.5	11	70	3.8	4.3
4.1	71	79	8.0	35	40	13.6	20	23	29.0	9.3	11	72	3.7	4.2
4.2	69	77	8.1	35	39	13.8	20	23	29.5	9.2	10.5	74	3.6	4.1
4.3	68	76	8.2	34	39	14.0	20	22	30.0	9.0	10.0	76	3.6	4.0
4.4	66	74	8.3	34	38	14.2	19	22	30.5	8.9	10.0	78	3.5	3.9
4.5	65	72	8.4	34	38	14.4	19	22	31.0	8.7	9.8	80	3.4	3.8
4.6	63	70	8.5	33	37	14.6	19	21	31.5	8.6	9.7	85	3.2	3.6
4.7	62	69	8.6	33	37	14.8	19	21	32.0	8.5	9.5	90	3.0	3.4
4.8	60	67	8.7	32	36	15.0	18	21	32.5	8.4	9.4	100	2.7	3.0
4.9	59	66	8.8	32	36	15.2	18	20	33.0	8.2	9.2	110	2.4	2.7
5.0	58	65	8.9	32	35	15.4	18	20	33.5	8.1	9.1	120	2.2	2.5
5.1	56	63	9.0	31	35	15.6	18	20	34.0	7.9	8.9	130	2.1	2.3
5.2	55	62	9.1	31	35	15.8	17	20	34.5	7.8	8.8	140	1.9	2.2
5.3	54	61	9.2	31	34	16.0	17	19	35.0	7.7	8.6	150	1.8	2.0
5.4	53	60	9.3	30	34	16.5	17	19	35.5	7.6	8.5	170	1.6	1.8
5.5	52	59	9.4	30	34	17.0	16	18	36.0	7.5	8.4	200	1.3	1.5
5.6	51	57	9.5	29	33	17.5	16	18	37.0	7.3	8.2	250	1.1	1.2
5.7	50	56	9.6	29	33	18.0	15	17	38.0	7.1	8.0	300	0.9	1.0
5.8	49	55												

In Determining the Accretion of a Felled Tree the volume is computed from actual measurements. By a few trials the top is cut off where the section contains as many rings as there are years in the period for which the accretion is desired, and the height of the tree at that time measured.

The difference in volumes past and present gives periodic

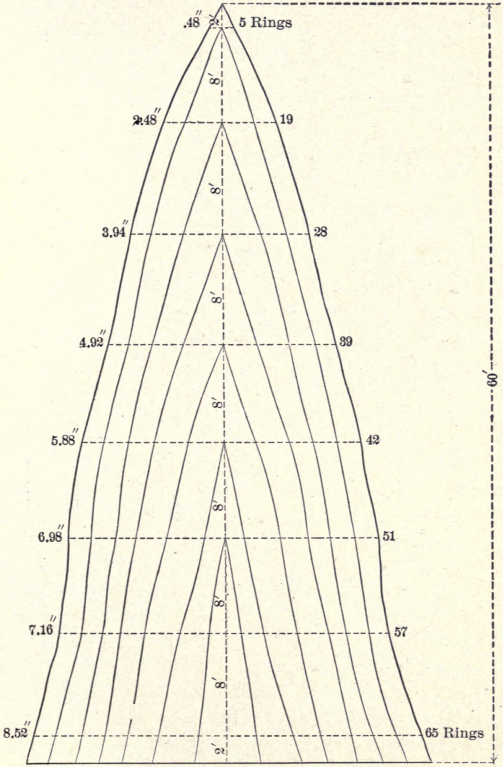

FIG. 62.—Diagram illustrating the progressive volume of a tree.

accretion. The diameter for both the past and present tree may be taken at the middle of the topless stem, and

volumes found by multiplying their respective cross-sectional areas at that point by the length of the topless trunk.

A more careful stem analysis of a tree affords detailed measurements from which the volume at any time during its lifetime may be determined very accurately. The following table of measurements of a Pine will furnish data for the calculation of its volume at different ages, and its progressive development is graphically illustrated in Fig. 62.

Height of Section in Feet.	Diameter Outside Bark.	Diameter Inside Bark.	Age.	Accretion in Inches During Past						
				10 Years.	20 Years.	30 Years.	40 Years.	50 Years.	60 Years.	70 Years.
2	9.3	8.52	65	.54	1.10	1.60	2.16	2.80	3.70	4.26
10	7.8	7.16	57	.38	.94	1.34	1.92	2.68	3.58	
18	7.1	6.98	51	.40	.96	1.42	2.25	2.81	3.49	
26	6.3	5.88	42	.42	.99	1.51	2.38	2.94		
34	5.7	4.92	39	.44	1.03	1.71	2.46			
42	4.4	3.94	28	.48	1.23	1.97				
50	3.0	2.48	19	.56	1.24					
58	.5	.48	5	.24						
60	Top									

The Accretion of a Forest for a given number of years is found by multiplying the accretion of the sample tree for that period by the number of trees per acre and the number of acres in the tract. If the trees are arranged in diameter classes, the accretion of each class is determined and the sum of accretions of all the classes taken as the accretion of the forest.

The Working Plan of a forest contemplates the economic management of the growing crop, so that there may be cut each year not to exceed the amount of the annual accretion; or, if worked on the rotation plan, so that there may be cut at any one time not more than the accretion

for the period of rotation, thus leaving the capital stock unimpaired. The methods of measurement described are used in outlining this plan.

The Estimation of Standing Timber is usually a matter of personal experience on the part of the estimator. No measurements are taken of trees, but the estimate is made by men of long experience in the woods. Sometimes their figures are very close, but more often they fall short of the actual stand of timber. Buying and selling timber lands is based on this method of determining the possible crop, both parties sending out their own estimators. The number of trees on typical areas, as an acre in each forty, may be counted, and the sizes estimated. Often all timber trees on a forty-acre lot are counted, and the number of logs per 1,000 feet board measure estimated.

For an inexperienced person a good method would be to caliper all trees on typical areas of the tract and then compute the stand from the cross-sectional area and the average length of timber stick, which could be estimated very closely after a little practice. The greatest difficulty in this work lies in the selection of typical areas and sample trees. All forestry measurements and estimates are only approximations, and it is often found necessary to modify working plans to meet new information and changed conditions.

MEASUREMENT OF LOGS AND LUMBER.

Logs are Measured in Feet Board Measure in Ordinary Practice by taking the length and diameter at the small end, and by reference to a table, the corresponding number of feet, board measure, is found, which it is assumed could be sawed from the log. This is not usually accurate, but seems to be sufficiently so for business purposes. Lumber is measured in square feet of surface of a board one inch

in thickness, commonly called board measure or B. M., for short.

Scaling Logs in Ordinary Practice is a Simple Matter. It is done after they are cut from the tree and marked, wherever convenient—in the woods, on skidways, on cars, on the river, or elsewhere. For straight, sound logs no experience is necessary, but for defective logs the scaler's judgment is depended upon to make proper deduction, so as to get out good lumber. Private scalers may be employed by those interested, but, to avoid possible litigation over sales, it is advisable to have the surveyor-general of logs and lumber for the district appoint an official scaler to do the work. The scalers enter in a book carried for the purpose the number of logs scaled, the length, the feet B. M., the number of each log if numbered, the section, township, and range where cut, and the markings. These books are kept on file in the surveyor-general's office or elsewhere for future reference.

There are Various Rules for the measuring of timber in this country. Those most commonly used are the Scribner and Doyle rules.

The Minnsota Law provides that Scribner's rule shall be the only legal rule for the survey of logs in that State, and that every log shall be surveyed by the largest number of even feet which it contains in length over ten feet and under twenty-four feet, and all logs of twenty-four feet or more shall be surveyed as two logs or more. As to what Scribner's rule is, the law does not say, and yet requires it to be posted in the offices of the surveyors-general of logs and lumber. The table on page 183 is a copy of Scribner's rule as posted there according to law.

Doyle's Rule is most commonly used. It is, however, open to the same objections as Scribner's rule, but is much more unjust to logs under sixteen inches in diameter. This rule is very simple and assumes that any log sixteen feet

SCRIBNER'S RULE.

Diameters in Icnhes.	Log Lengths in Feet.					
	12	14	16	18	20	22
8	24	28	32	40	44	48
9	30	35	40	45	50	55
10	40	45	50	55	65	70
11	50	55	65	70	80	90
12	59	69	79	88	98	108
13	73	85	97	109	122	134
14	86	100	114	129	143	157
15	107	125	142	160	178	196
16	119	139	159	178	198	218
17	139	162	185	208	232	255
18	160	187	213	240	267	293
19	180	210	240	270	300	330
20	210	245	280	315	350	385
21	228	266	304	342	380	418
22	251	292	334	376	418	460
23	283	330	377	424	470	518
24	303	353	404	454	505	555
25	344	401	459	516	573	631
26	375	439	500	562	625	688
27	411	479	548	616	684	753
28	436	509	582	654	728	800
29	457	539	609	685	761	838
30	493	575	657	739	821	904
31	532	622	710	799	888	976
32	552	641	736	828	920	1012
33	588	686	784	882	980	
34	600	700	800	900	1000	
35	657	766	876	985	1095	
36	692	807	923	1038	1152	
37	772	901	1029	1158	1287	
38	801	934	1068	1201		
39	840	980	1120	1260		
40	903	1053	1204	1354		
41	954	1113	1272	1431		
42	1007	1175	1343			
43	1046	1222	1396			
44	1110	1295	1430			
45	1139	1315	1587			
46	1190	1380	1656			
47	1242	1445	1728			
48	1296	1512	1818			

long is equal in feet board measure to the square of the diameter reduced by four. Thus a log twenty-four inches in diameter and sixteen feet long would be estimated as $(24-4)\times(24-4)=400$ feet board measure. If it is eighteen feet long it would be estimated as $400\times\frac{18}{16}$ or 450 feet. This rule is so simple that any one acquainted with figures can easily construct a working table. A table of this sort is given on page 185.

Scribner's and Doyle's Rules are not Adapted to the measurement of logs that are to be used for paper-pulp, and here probably the fairest method is to caliper the logs in the middle, allowing for the bark, and compute the volume as a cylinder with that diameter. This gives a close approximation of the cubic contents, which is what is wanted. In the case of long logs that taper very fast, these rules will also fail to give a fair measurement, and in such cases logs will frequently scale more by these rules after they are shortened a few feet, which is absurd. These points should be kept in mind in using them. The Dimick rule is used in the Adirondacks for spruce pulp wood.

The New Hampshire Rule for Measuring Timber is in use in New Hampshire. Here an artificial cubic foot has been made by law and is equal to 1.4 of the standard cubic foot. This is a caliper rule, which gives the contents of a log from length and diameter at middle, seven-eighths of an inch by the structure of the rule being thrown out for the bark. The law on the subject is as follows:

"All round ship timber shall be measured according to the following rule: A stick of timber sixteen inches in diameter and twelve inches in length shall constitute one cubic foot, and in the same ratio for any other size and quantity; forty feet shall constitute one ton.

"All round timber the quantity of which is estimated by the thousand shall be measured according to the following rule: A stick of timber sixteen inches in diameter and

DOYLE'S RULE.

Diameters in Inches.	Log Lengths in Feet.					
	12	14	16	18	20	22
8	12	14	16	18	20	22
9	19	22	25	28	31	34
10	27	32	36	41	46	50
11	37	43	49	55	61	67
12	48	56	64	72	80	88
13	61	71	81	91	101	111
14	75	88	100	112	125	137
15	91	106	121	136	151	166
16	108	126	144	162	180	198
17	127	148	169	190	211	232
18	147	171	196	220	245	269
19	169	197	225	253	280	309
20	192	224	256	288	320	352
21	217	253	289	325	361	397
22	243	283	324	364	404	445
23	271	313	359	406	452	496
24	300	350	400	450	500	550
25	331	386	441	496	551	606
26	363	423	484	544	605	665
27	397	463	530	596	661	726
28	432	504	566	648	720	792
29	469	547	625	703	782	860
30	507	591	676	761	845	930
31	547	638	729	820	912	1004
32	588	686	784	882	980	1078
33	631	736	841	946	1051	1156
34	675	787	900	1012	1125	1237
35	721	841	961	1081	1202	1322
36	768	896	1024	1152	1280	1408
37	817	953	1089	1225	1361	1497
38	867	1011	1156	1300	1446	1590
39	910	1070	1225	1379	1530	1684
40	972	1134	1296	1458	1620	1782
41	1027	1198	1369	1540	1711	1882
42	1083	1264	1444	1625	1805	1986
43	1141	1331	1521	1711	1902	2091
44	1200	1400	1600	1800	2000	2200
45	1261	1471	1681	1891	2102	2312
46	1323	1544	1764	1985	2206	2426
47	1387	1618	1849	2080	2312	2542
48	1452	1694	1936	2178	2420	2662

twelve inches in length shall constitute one cubic foot, and the same ratio shall apply to any other size and

quantity. Each cubic foot shall constitute ten feet of a thousand."

THE NEW HAMPSHIRE RULE.

Diameters in Inches.	Log Lengths in Feet.					
	12	14	16	18	20	22
8	26	30	35	39	43	48
9	33	38	43	50	54	60
10	41	48	54	61	68	75
11	50	57	66	74	82	90
12	58	69	78	88	97	108
13	70	80	92	103	115	126
14	80	93	106	120	133	146
15	91	107	123	137	153	168
16	104	122	139	157	174	191
17	117	137	157	177	199	216
18	132	154	176	198	220	242
19	148	171	191	221	245	270
20	163	190	217	244	271	299
21	180	210	240	270	300	330
22	197	230	262	296	329	362
23	216	251	287	323	359	396
24	235	274	313	352	391	430
25	255	297	339	383	424	467
26	276	322	367	413	459	505
27	297	347	397	446	496	554
28	319	373	426	479	533	586
29	343	400	457	514	572	629
30	367	428	489	550	611	672
31	391	457	514	588	653	718
32	417	487	557	626	696	765
33	443	517	592	666	740	814
34	471	549	628	707	785	863
35	499	583	666	749	832	916
36	528	617	704	792	880	969
37	558	651	744	837	930	1023
38	589	687	785	883	981	1079
39	620	723	827	930	1034	1137
40	543	685	799	914	1028	1142

The Number of Feet B. M. which May be Obtained from a Log varies with the management of the cutting, the width of kerf, the width of boards, whether one- or two-inch boards, or some of both, are cut from the same

log. Usually the cut exceeds the scale. Take, for example, a log sixteen inches in diameter at the small end, eighteen inches at the middle, twenty inches at the large end, and twelve feet long. Such a log contains about 21.2 cubic feet. The official scale gives 119 feet B. M., which is equal to 9.9 cubic feet. The actual cut should give 155.75 feet B. M., or thirteen cubic feet of lumber, the slab would be about 5.3 cubic feet, and the kerf (sawdust) about 2.9 cubic feet. From this it would appear that the Minnesota official scale (*i.e.* Scribner's Rule) gives the seller 46.7 per cent. of his log, while the mill turns out 61.3 per cent. in lumber, 13.7 per cent. in sawdust, and 25 per cent. in slab. The producer loses 53.3 per cent. of the scaled log; but that is not all his loss. In marking logs to be cut the undercutter allows at least three inches over the required length to cover loss in checking; that is, a log scaled at twelve-foot length would really measure twelve feet and three inches or more.

The Percentage of the Logs on which the seller or producer gets returns by Scribner's Rule varies with different sizes and shapes. The table on p. 188 will serve as a comparison:

In practice these discrepancies are equalized as the result of the ordinary trade relations, and are not liable to work serious injustice under present conditions, and are here stated only to call attention to our crude methods of measuring timber.

INSTRUMENTS USED IN FOREST MENSURATION.

The Equipment of a Forester, while not extensive, must be complete for the work in hand. He surveys the land, lays out roads and ditches, cuts down trees and saws them into logs, measures diameters of logs and growing trees, takes heights of trees, determines rates of growth, estimates and measures timber and cordwood, and maps and plats

TABLE SHOWING PERCENTAGE OF ACTUAL VOLUME OF LOGS ON WHICH THE SELLER GETS RETURNS ACCORDING TO SCRIBNER'S RULE.

Diameters, Inches.	Lengths, Feet.	Scale.		Volume, C. F	Per Cent. of Actual Volume Scaled.
		B. M.	C. F.		
21–22	16	304	25.3	40.3	62.8
18–19	22	293	24.4	41.1	59.4
18–21	16	213	17.9	33.2	53.9
16–18	16	159	13.3	25.2	52.8
15–22	16	142	11.8	29.9	39.5
1 –16	14	125	10.6	18.3	57.9
16–20	12	119	9.9	21.2	46.7
14–18	12	86	7.2	16.8	42.9
14–15	12	86	7.2	13.8	52.2
10–14	20	65	5.4	15.7	34.4
11–13	16	65	5.4	12.6	42.9
11–12	16	65	5.4	11.5	47.0
11–15	12	50	4.2	11.1	37.8
10–12	16	50	4.2	10.6	39.6
8–10	16	32	2.7	7.1	37.8
6– 9	16	16	1.3	4.9	27.1
9–11	16	40	3.3	8.7	38.1
8–11	16	32	2.7	7.9	33.8
8–12	16	32	2.7	8.7	30.6
8–13	16	32	2.7	9.6	27.8
8–12	12	24	2.0	6.5	30.6
8–10	12	24	2.0	5.3	37.7
9–11	12	30	2.5	6.5	38.2

his work. Where there has been a survey of land by the government, as is common, he will not be called upon to make one, as maps sufficiently reliable for his purpose may be had from official records; but to meet all the requirements of his position, the forester should be an expert surveyor, and provided with all the necessary instruments for the work, including drawing instruments, tables, stationery, etc., for office work, in mapping and platting his field observations. The work of forestry mensuration is concerned mainly with taking diameters and heights of trees, determining the areas on which they stand and the rate of growth.

For Measuring Land Acres the ordinary steel tape, graduated on one side in feet, tenths, and hundredths, and on the other side in links for convenience in computing acreage, is used, the 100-foot length being preferred. For the same purpose a steel chain is also used, and with the chain or tape should be a set of marking-pins and ranging-poles. In laying out small rectangular areas, as a sample acre, a compass, a cross-staff head, an angle mirror, or an angle prism is used, but for more extended surveys and for road and ditch work a transit and level would be advisable, while for the location of lost corners the magnetic compass might have to be resorted to.

For the Rough Land Measurement of a Valuation Survey a Steel Chain Thirty-three Feet Long is used. This short chain is attached to a stout leather belt about the waist of the tallyman, whose hands are then free to carry the tally board holding notebook or tally blanks, and to work with a lead-pencil. A small magnetic compass by which the tallyman directs his course is fixed on one corner of the tally board.

The Diameters of Trees and Logs are taken with a **pair of wooden calipers** of convenient size for the timber of the district. A limb or scale bar, graduated in inches and tenths, has a fixed arm standing out at right angles at one end, while a second arm is movable along the bar so that the trunk of a tree may be enclosed between them and the diameter read directly from the scale. The fixed arm is held in place by a screw so that it may be removed for packing and transportation, or so that a broken part may be replaced. The other arm has an adjustable plate which keeps it at right angles to the scale bar when pressed against the tree. Sometimes the circumference of the tree is measured with a steel tape, one side of which is graduated to give diameters of circles whose circumferences are read from the other side.

The Heights of Trees are determined by means of a most convenient and useful little instrument, called Faustman's mirror hypsometer. The distance of the observer from the tree is measured with a steel tape, and the instrument adjusted to that distance by the slide and vertical scale. The top and bottom of the tree are then sighted

FIG. 63.—Calipering a tree.

and the readings of the marginal scale where the plumb-line crosses it added to or subtracted from each other, according as the eye of the observer is above or below the level of the tree. The vertical scale on the right-hand side runs upward from zero to 60, and is continued on the left-hand side to 110. If the distance is less than sixty, the lower index mark of the slide where the plumb-line is attached should be brought in a position coinciding with the required reading on the right-hand scale. If

the distance is more than sixty the slide must be taken out and reversed so that the upper index mark on the slide coincides with the required reading on the left-hand vertical scale.

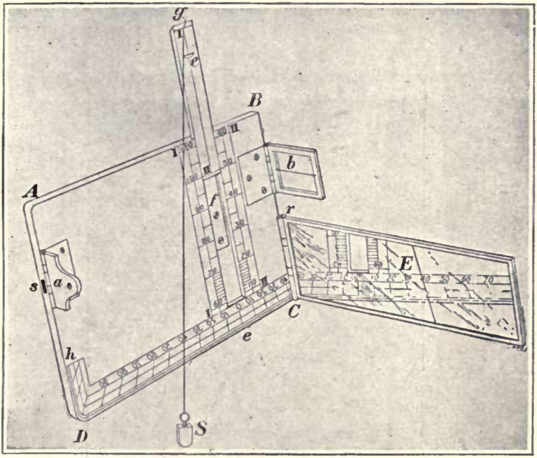

FIG. 64.—Faustman's mirror hypsometer. *ABCD*, frame of instrument; *E*, mirror in which scale is reflected; *a*, eyepiece; *b*, cross-wire on which object is sighted; *ge*, slide and vertical scale for distance of observer from tree; *f*, spring to hold slide in place; *h*, marginal scale which gives height of tree.

This instrument may also be used in taking levels and grades, and may be mounted on a Jacob's-staff or tripod, but is more often used in the hand. Another instrument, called "Baummesser" by the Germans, mounted on a tripod, is used to take heights, and by means of a stadia attachment, the diameter at any point on the trunk of the tree may also be measured. After some practice with

one of them, a person may become sufficiently expert in estimating the heights of trees to get on without the instrument.

The Rate of Growth of a Standing Tree may be determined by removing from the trunk a small cylinder of wood with a hollow auger called an accretion-borer. On this section of wood the annual rings are counted and

FIG. 65.—The mirror hypsometer in use.

their width measured with a pocket rule graduated in inches and tenths, or in millimeters. Where the growth has been slow, and the rings are close, a pocket lens may be necessary to enable one to count them. When a fuller determination of the rate of growth is desirable, trees are felled with an axe, or with a saw, and cut into logs. A small saw is easier to carry around, but a longer, heavier saw does much faster work. The common logging saw

of the Minnesota woods is six feet in length. In making an examination of the end of a log, the rough graining of the saw must often be smoothed away before the rings

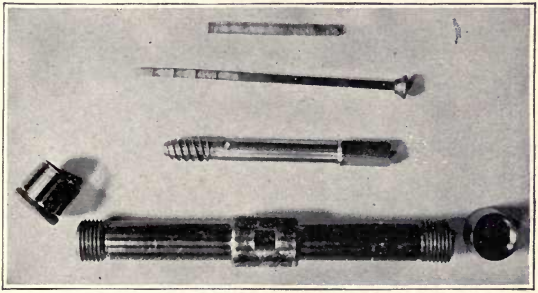

FIG. 66.—The accretion-borer, showing handle, hollow auger, with drawing-pin, and a core of wood extracted. The handle is hollow with screw caps, so that the other parts may be carried inside when not in use.

can be counted readily, and this is well accomplished with a sharp knife, cutting a broad V notch from the centre to the circumference.

Miscellaneous Instruments used by the forester. For marking logs, blazing trees, cutting away limbs, etc., a hand axe is a desirable addition to the equipment. It should be small, so as to be conveniently carried in the pocket or in the belt, and should have a leather guard to protect the edge when not in use. As saws and axes will not keep sharp long if used, a grindstone, whetstones, files, and saw sets should be provided. In calipering trees on a small area across which it is necessary to make several trips, the surveyor avoids repetitions by marking the bark of each tree, as he calipers it, with a metal scratcher carried in one hand. Sometimes a pair of climbers are used to get

into the top of a tree for the purpose of measuring upper limbs and diameters. The number of feet board measure in logs is ascertained by means of the ordinary log rule, Minnesota standard, used by scalers, and a board rule measures the lumber as it comes from the sawmill.

FIG. 67.—Using the accretion-borer on the trunk of a tree.

A Camping Outfit is necessary where the work of the forester is done in the depths of the forest, far from habitations and railroads, and perhaps a wagon and a team of horses or pack horses should be provided for moving camp and hauling supplies. If the area to be worked over is great, the chief of the party should have a good saddle horse, so that he may get over the country quickly and lay out work for his subordinates who operate on foot.

CHAPTER XI.

FOREST PROBLEMS.

THE object of this chapter is to give general suggestions which may be applied to a variety of conditions, and not to prescribe exact treatment for any special forest problem. It has seemed that certain methods of treatment could be best given in this way.

1. A has a swamp covered with thrifty Black Spruce, in all about seventy-five acres. Last year he got 500 Christmas trees from it, which he sold at eight cents each. There is also some Tamarack and Pine on the higher land. For what trees can this land be used for greatest profit? How long does it take to grow Christmas trees?

Answer: If the Black Spruce are thrifty, it is a very sure indication that the soil is not overly wet during the summer, and that it is in very good shape for Tamarack or other more valuable tree. The Black Spruce is a very slow grower, and it is doubtful if it should be encouraged under any condition. Our native White Spruce grows much faster, and this would be much the most profitahle of any of our native trees for paper pulp; but some studies by the Minnesota Experiment Station seem to show that the Norway Spruce could be grown at even greater profit for paper pulp. This tree is fully as rapid a grower as the White Spruce, nearly as hardy, and the seed of it is much more easily obtained. If it is thought desirable to use this land for pulp wood, a small bed of spruce seed-

lings should be made up near by, in which should be sown White or Norway Spruce seed, and when the seedlings are three or four years old they should be transplanted to the swamp. It would take at least fifteen years to grow Black Spruce to a height of six feet for Christmas trees, while the Norway Spruce could probably be grown to the same height under same conditions in eight years. About 1,800 Christmas trees can be grown on one acre of land to a height of six feet and with a spread of five feet. Spruce may be grown closer together than most other trees for this purpose, because the shaded branches are not easily killed out.

2. B has a Tamarack swamp in Southern Ontario of 800 acres, from which he has cut all the timber big enough for ties. There is practically no demand for the smaller post timber at present, and he asks what he should do with it, and if it will pay him to hold it. The land seems to be well stocked with young trees of various ages, some of which have been somewhat broken down in getting out the larger tie timber.

Answer: Probably the best treatment would be to let it alone. If the land is quite wet, there is very little chance of fire doing much damage to it. If, however, it is liable to be dried out it would be a good plan to take some precaution to protect it from fire, if it can be done without too much expense.

The Tamarack grows very rapidly, and there is perhaps no tree that will pay better than this, providing the taxes are not too high. While there may be no demand at present for the smaller stuff for fence-posts, yet within a few years such a demand is inevitable, as the more accessible Tamarack is now being rapidly sought after for such purposes, and is being shipped in large quantities to the prairie farms. Such a Tamarack swamp, if carefully looked after, is capable of continuing itself indefinitely

and producing a fairly good annual revenue. The advisability of perpetuating such a swamp in Tamarack would depend largely on the demand for hay land, for which purposes such land is generally well adapted.

3. A has 500 acres of dry sandy land. The soil blows badly, and is too light for grain. Clover does very well on this land when protected with snow in winter, but is liable to kill out in open winters. The subsoil is clay.

Answer Such land should never have been cleared for agricultural purposes, and the sooner it can be got into tree-growth again the better for the soil. The land should be seeded down with rye or other crop, or possibly with clover, until something of a sod is formed. In this sod Jack Pine might be planted, or it is very probable that Jack Pine would come well from seed sown in furrows made in the sod. After the Jack Pine is well established about 500 Norway or White Pine per acre could be planted to advantage. This should receive only a moderate crowding by the Jack Pine, and should be protected from too much crowding until it can take care of itself. This number of trees would be enough to make a well-stocked acre at maturity. Since the land has a heavy subsoil, the chances are that there would be a good tree-growth, as trees are more influenced by subsoil than by the surface. If such land is very accessible, it would probably pay better to grow green crops on the soil, and by careful rotation use it for agricultural purposes, for which it may be fairly well adapted if carefully managed.

4. B has 600 acres of Jack Pine, four to twelve inches in diameter. The soil is typical of Jack Pine land, being very sandy and unfit for agriculture. What is the best treatment of it?

Answer: Such land is only fit for timber growth, and Jack Pine is probably the most profitable tree that can be grown upon it if it can be sold as fuel. The aim should

be to keep out fires, and to cut the trees on the selection plan, removing the larger ones when they attain a diameter of ten inches. It may, however, be best to cut clean on certain parts at each cutting, but the cuttings in such cases should not be so large but what the trees near by will seed the land. This tree has wonderful regenerative power, and soon covers the soil with a new growth. It is rather impatient of shade, and the young seedlings do not do well under the old trees. It often happens that the cones on Jack Pines remain upon the trees unopened for a long time, and often fire sweeps over the land which scorches them, causing them to open and shed their seeds. As fire is to be avoided on such land, in order to protect the young growth, it may be best to gather the cones, and after roasting them slightly so that the scales open, scatter the cones broadcast over the cut-over portions. If timber is wanted, it would be worth while to try to secure a stand of Norway Pine seedlings.

5. A has a dry, sandy prairie, the soil of which blows badly when it is broken up. The trees blow out, and it is of very little value for agricultural purposes. Can it be used for forestry? The subsoil is fairly good, and there is standing water at a depth of about ten feet.

Answer: Under such conditions trees should do well after they have once become established. The difficulty is in getting the land stocked. By seeding the land down to clover, with oats, in the spring of the year, the oats would come up quickly and prevent the blowing out of the soil early in the spring, and the clover would come along and probably make a good showing the next year. After the oats and clover have started, about one-half the land can be planted in strips not more than sixteen feet wide and twenty-four feet apart. If these strips are planted with almost any of our hardy trees, they should do well. For this purpose the White Willow would be

very desirable, but seedlings of Box-elder, Green Ash, or Norway Pine should also do well. The strips of land in oats and clover will afford sufficient protection to the planted strips to protect them from wind injury. After these strips are established and two or three years old the intervening spaces may be broken up and planted without danger of any further wind injury.

6. A has a piece of burned-over timber land on which there are scarcely any seed-bearing trees of value; the valuable Pines have all been destroyed by successive burnings. Most of the land is perhaps two miles from any seed-producing White Pine, which was the most profitable tree on this land, and is undoubtedly now the most profitable tree that this soil can produce. He would like to have it restocked with White Pine. How should he go to work to do it?

Answer: Since the seed-bearing trees are so far distant from the land, there is no use depending upon them for restocking the soil with their seedlings, and the Poplar, Birch, and Bird Cherry will undoubtedly soon reign supreme here, if they do not already. The best treatment is probably to gather White Pine seedlings that are under one foot in height from the near-by forest, if they can be obtained easily, and set them out, about twenty feet apart each way, amongst the brush now found on the land, taking care to make a little clearing, as it were, where each tree is planted. The tendency will be for the worthless trees now growing on the land to smother out the Pines before they get started, and it will be necessary each summer for several years to go over the land and cut away those trees that are crowding the young Pines too severely. After these young Pines have become established it is probable that they will be able to take care of themselves in competition with the inferior species, and then the crowding which they receive from the latter will be

a good thing for them, as it will cause them to take on an upright growth. Plantings of this kind will probably cost somewhere about five dollars per acre, and if the work is carefully done in the spring, just before the growth of young pine starts, there should be scarce any failures. In setting out the seedlings it is important that they be kept in water or in damp moss from the time they are pulled out until they are put into the soil again. They must never be allowed to even appear dry.

7. B has land in Northern Michigan covered with a mixed growth of Pine and Poplar. The Poplar is about twelve inches thick and overtops the Pine, which varies from four to eight inches in diameter and from twenty to forty feet high. What treatment would be best to secure an even stand of White Pine?

Answer: While the Poplar is hardly marketable at present, yet it should be removed even if the material taken out hardly pays for the expense of so doing. This should be done in order to give the Pine a chance to shoot upward. After the Poplar is removed the Pine will probably stand for several years without serious crowding, when it should be thinned to obtain best results.

8. A has 2,000 acres of burned-over land in Wisconsin. This has quite a number of crooked and branching seeding trees, probably sufficient to seed the land, but the soil is so covered with raspberries, grass, and Poplar that the Pine has very little chance to grow.

Answer: The best way for giving a chance for the pine seed to grow is to drag the land in good seed years as well as can be with a drag made of oak branches or logs. This will tear up a good deal of grass or bushes and make a loose surface soil in which the Pines can take root; but the next year the weeds will again start, and will destroy the Pine unless they are held in check in some way. This is probably best done by going over the land in June and July,

and cutting off some of the weeds where the Pines have seeded thickest. This practice should be followed at least two years, after which but little attention of this sort will be needed, as the Pines will probably be able to take care of themselves from then on. If the land can be used for sheep pasture for one or two years, most of the weeds and bushes will be destroyed, and the land will be left in improved shape for the treatment outlined in dragging the land to get it into good shape for a seed-bed. In fact, without any further treatment the Pine will probably come in unless the land is very heavily pastured.

9. A has 2,000 acres of land in Northern Minnesota without any seeding trees. How can he secure a stand of Pine upon the land?

Answer: In such a case the best way is probably to set out Pine seedlings, pulled from the woods, setting them about twenty feet apart each way. This will require about 400 plants per acre. If the work is done early in the spring there should be no great trouble about securing a good stand. These trees will be crowded by weeds on the land, which may help them to take an upright growth, but they should be watched, and the weeds kept in check, if they are liable to overcome them. After a few years, the Pine will be improved by the crowding of Poplar and Hazel brush, which is generally found upon such soil.

10. A has a half section of moderately good land, covered with an even-growth of White and Norway Pine. He would like to maintain a stand of Pine on this tract—not that he thinks it especially profitable, but that it would prove an interesting experiment.

Answer: Even-aged Pine is very difficult of renewal without clean cutting, and it is quite out of the question to handle such tracts to advantage on the selection system. There is practically no such thing as even-aged Pine over

large areas in this State. It is probable that this land could be best renewed by the group or strip method. The land should be burned over clean after cutting, care being taken to protect any good groups of seedlings that may occur. A stand of young seedlings should be secured on each piece of land cut over before further cutting is done. If grass or brush is coming in too fast, it will probably be a good plan to go over the land with a log-drag in August of the best good seeding year after cutting, so as to loosen the soil, that the seed may have a good chance to start. Grass and weeds often prevent the growth of Pine seed, or even kill out the young seedlings after they are started.

11. A would like to have a good shelter-belt about the buildings on his prairie farm, in Central Minnesota, and would like if it could be made to furnish fence posts and fuel. He could use ten acres for this purpose.

Answer: He will probably come nearest to accomplishing this if he makes a solid planting of White Willow, as recommended on page 165.

12. C has a farm on rolling prairie. It is all under cultivation or used for pasture. He feels the necessity of having a home supply of fence posts and light fuel. Thinks of putting his wood lot on the rich bottom land. The soil is a sandy drift, some ridges being more sandy than others, and in a few places are bare from washing.

Answer: Since the bottom land resists drought better than the high land, it would be better to keep it for agricultural purposes, and to place the trees on the ridges, where the soil is too bare to yield a return from agriculture. He could probably plant White Willow in these locations to good advantage, and get what he needs in fence posts and a considerable amount of summer fuel. It is probable that on such land there would be a yield of about three cords per acre of fuel wood per year, much

of which material could be used for posts. These trees should be cultivated until they cover the land well. They should begin to yield some fuel within six years from the time cuttings are planted, if they are set two feet apart in rows eight feet apart.

13. A farmer living on the open prairie in Northwestern Iowa wants a windbreak and wood lot; more particularly desires a windbreak for buildings and a shelter for stock. Does not think of raising firewood or his own fence posts. Can a windbreak be worked to advantage as a wood lot in such a case?

Answer: Under such conditions the windbreak should be made somewhat wider than recommended on page 57 so as to include as much area as to give the wood desired. In cutting under such conditions, it would be desirable to cut not more than one-half of any portion of the windbreak at one time, so that its value as a windbreak would not be impaired at any time. Working in such a way would require a rotation period of about ten years. It would probably be best to plant this largely with White Willow; but if the soil is heavy or somewhat inclined to be moist, it would be a good plan to put in some Soft Maple and Box-elder.

14. A has five acres in Catalpa in Eastern Kansas which were planted seven years ago, 4×4 feet apart, to see what could be done in growing them for telephone poles. He finds that they are so very crooked and branching that they will be worthless for this purpose, and asks what is the best treatment.

Answer: Catalpa will seldom grow straight enough for telephone poles when managed in this way. The best treatment for this tree is to allow it to grow naturally until five years old, and then cut the whole stand off at the surface of the ground in winter or early spring, and allow but one sprout to grow from each stump. The

growth in this way will be very vigorous and straight. In this particular case it would probably be best even now to cut them off in this way.

15. A has six hundred acres of mountainous land in Eastern New York covered principally with a mixed growth of Birch, Chestnut-oak, Red Oak, Poplar, Hemlock, and a few Hard Maple. He wishes to make it into a sagar orchard, for which he thinks it especially adapted, and wishes to know the best method of procedure.

Answer: The best method will be to secure a stock of seedling Maples. These may be bought outright or grown in a small nursery from seed. When these are secured, probably the quickest results will be obtained by removing the entire tree growth from the land and planting out thrifty Maple seedlings eight feet apart each way among the stumps, and rigidly excluding all cattle and fires. If, however, quick results are not so much desired as economy, the same end may be accomplished by gradually thinning out the timber now on the land and planting strong seedling Maples wherever there is light enough for them to grow; but after planting them, they should receive some little attention by "cutting back" any trees that may crowd them. Advantage should also be taken of the Maple trees now on the land, and sufficient thinning done to give them a chance to reproduce themselves. It is very likely that there are, in places, some seedling Maples that can be spared for transplanting elsewhere.

16. A has a piece of stony land in Western Massachusetts that seems to be about run out. It was formerly used for farming. He asks if it is desirable to plant it to Chestnut, for which purpose he thinks it adapted.

Answer: It is probable that, all things considered, Chestnut would prove the most profitable tree that could be grown on this land, since it is easily started, grows vigorously, and at fifteen years of age will probably furnish

trunks big enough for post timber and give good crops of nuts, for which there is an increasing demand. This tree is one of the quickest to renew itself from the stump, and may be successfully managed as a coppice. The best way of starting will probably be to thoroughly plough the land and get it into as nice condition as for a crop of corn. As early in the spring as the land can be worked, make furrows with a plough, seven feet apart, and sow the nuts—putting them about six inches apart in the furrow and cover two inches. Later sow corn or plant potatoes between the rows, and keep the rows thoroughly cultivated all summer. Cultivation should be given each year thereafter until the trees shade the ground. If the seeds have come well, the trees must be thinned out so as to prevent too much crowding from time to time.

It is important in storing the nuts over winter that they be mixed with plenty of sand or fine loam, as they require very careful handling to prevent their spoiling.

17. What kinds of trees are best adapted to use for live fence posts? Should the wires be nailed directly to the tree, or on blocks of wood which are fastened to the tree?

Answer: Probably the best tree for a live fence post is one of the Willows or other hardy tree. Where the White Willow is used for this purpose, there is no special objection to nailing the wire directly to the tree, except that the tree will soon grow over the wire, and it cannot then be removed. If it is thought that the wire might be removed within a few years, it would be much the better plan to nail it on to blocks of wood which are nailed to the tree. Willow trees which are used in this way as live fence posts may be cut off about a foot above the top wire and allowed to reproduce themselves. Such trees, if properly managed, will often produce a large amount of firewood, as well as afford good fence posts.

18. We have thirty acres of rather wet land which we do not expect to use for many years except as pasture. Would it pay to grow some White Willows on a portion of it, and would they interfere with its value as pasture?

Answer: If the land is not heavily pastured, it might be a good plan to grow a few groups of willow on it, as they will furnish some protection to the stock, and do not interfere materially with the pasturage value of the land. Scattered trees might also be grown, as they would not seriously interfere with the growth of grass under them where the land is moist; but it would not be desirable to encourage a very thick growth on the land, since it is much more valuable for pasturage than it would probably be for growing wood.

19. B has come into possession of fifty acres of bluff land along the Mississippi River, in Southern Minnesota. The land is of good quality, but too much broken for agriculture, and when used as pasture it washes badly. The southern slopes are nearly bare of trees, but the other slopes are well covered with White Oak, Hard Maple, Basswood, and Elm, with some Hackberry, Wild Black Cherry, Black Walnut, and Butternut. It has been pastured for twenty years, and consequently there are no young trees coming on. He desires to preserve it as a wood lot, since it has become of little value for pasture.

Answer: The first thing to do is to keep out the cattle, as they destroy all the young seedlings that start, and prevent any natural regeneration. In good seed years it might pay to loosen the soil, where it could be done easily, in portions that are not especially liable to erosion, so as to give the seeds that fall a good chance to grow. It would also be well to gather Black Walnuts and Acorns, and plant them in especially favorable locations. Improvement cuttings should also be made where needed.

20. A has five acres of overflow lands along the Mis-

sissippi River. This is about four feet above the low water mark. It is, however, so liable to freshets in the spring that it would not be safe to use it for agricultural purposes, and it is not desirable for pasture or meadow. It is now covered with a heavy growth of White Maple and Cottonwood, and some White and Red Elm. What is the best way of managing it?

Answer: It would seem quite probable that the White Maple will become the most valuable wood of any now on the land, and it should be encouraged by cutting out the Cottonwood wherever it crowds, and also the White and Red Elm. The aim should be to have a good stand of White Maple, as it seems probable that this will produce by far the most profit. This tree makes a very rapid growth on good soil, and the wood is used for a variety of purposes. If the Maples do not thickly cover the ground, there may be some chance for good pasturage under the trees; but under the best conditions there would be no opportunity for pasturage. This land would possibly yield about 500 feet board measure per acre per year if well stocked. Such land will probably be used for meadow when the country is better settled, but this is perhaps no objection to using it for growing maple for the next twenty years.

21. A has a piece of gravelly land. It was originally covered with a growth of Bur. White, Red, and Scarlet Oak, but was cut over about thirty years ago, and at present has a rather thin stand of stunted trees, many of which are sprouts from Bur Oaks. It is burned over every year. The land is of very little value for agricultural purposes.

Answer: On such land the increase is very little, and there will be no profit in holding it for tree growth if it is taxed at a high rate. If, however, the rate of taxation is low, it is quite likely that the trees will yield a fairly

good return. It should be the aim of the owner to keep out fires, and so encourage the growth of underbrush and leaf mould, as this protects from drying out in summer, which is important on such land. The large trees that are decaying had better be cut out, and the younger growth favored by occasional thinnings, where too much crowded.

22. A has a meadow which is subject to overflow in the spring of the year. The stream which runs through it is liable to sudden rises, and has made many channels for itself, and is continually making new channels. The land affords fairly good pasturage, but the cutting of new channels by the river is a source of great annoyance and loss. Is there any way that this can be prevented by planting trees?

Answer: Such streams may be permanently straightened out by planting Willows across the cuts made, so as to confine the waters to a straight course. By this treatment a stream soon clears out a deeper main channel for itself, and the old high water channels gradually fill up with the sediment from the water which sets back into them from the river at times of freshet. The banks of the stream should also be protected from washing by planting Willows on them. For this purpose Willow cuttings of large size should preferably be used. They should be not less than two inches in diameter and six feet long, and be put at least three feet in the ground where exposed to erosion.

23. A has forty acres near Minneapolis, covered mostly with a heavy stand of Sugar Maple, twenty-five years old, and two or three acres of Tamarack, Elm, Basswood, and Oak. What treatment would be more profitable than to clear up for pasture or other purposes?

Answer: Such land as this is probably much more valuable for agricultural purposes than for forestry, un-

less it is stony or on steep hillsides, for the tree growth indicates a strong, valuable soil, and its being located near a large city should enhance its value for dairying or similar purposes.

24. Some neglected lowlands have become partially covered with Cottonwoods and Willows, some of which are a foot or more in diameter. These trees are in irregular patches, covering perhaps two-thirds of the tract. The lowest places are quite wet and boggy. What income might be derived from a careful management of the growing trees?

Answer: Very little profit can come from it in its present condition, except as it may be useful for pasturage. If, on further consideration, it is decided that it will be more valuable for forestry purposes than for pasturage, it would probably be best to encourage a growth of White Maple, the seeds of which could be sown in furrows or in patches, in June. The Cottonwood should be kept out as much as possible, as, since it is well adapted to this class of soil, it is liable to drive out everything else, and there is very little profit from the growing of it.

25. B has forty acres of land covered with Maple, White Oak, Birch, Hackberry, and Elm. He cuts his fuel from it, and makes sugar from the Maple each year, and finds it fairly profitable. There are, however, no young trees coming on, the ground being entirely bare, and it looks as though in the course of time the old trees would ripen up, and there would be nothing to take their places. The land is so rough that it would not be profitable for agriculture nor especially desirable for pasturage.

Answer: The reason why there is no young growth coming on is probably because the land is closely pastured, since the foliage of the Maple, Elm, Birch, and Oak is readily eaten by stock. The first thing to do is to keep out the cattle, so that the young seedlings may

have a chance to become established. If the leaf canopy is rather thin, so that the light has encouraged the growth of grass under the trees, it would be a good plan to break up the soil just before the seed falls, in good years. Possibly furrows could be made through the woodland with a plough; but if too rough for this, then it can be broken up by the dragging of several logs tied together over the land. It would be a good plan to keep out everything but the Sugar Maples, since these will undoubtedly be the most profitable, both for sugar and for fuel. As these seedlings come on they should be encouraged to cover the land, by letting in a little light occasionally, if necessary. This may be done by removing some of the old trees that are past their prime. After the young trees are seven or eight feet high, no harm would come from the pasturing of stock among them for a few years, unless the land was so heavily pastured that the treading of the stock about the roots was injurious. If treated in this way there should be no trouble about securing a good stand of young Maples to come on and take the place of those which are maturing.

PROBLEMS BY DR. C. A. SCHENCK.

The following five problems, numbered 26 to 30, are by Dr. C. A. Schenck, the head of the Biltmore Forest School and an eminent authority on forestry mathematics:

26. A LONGLEAF PINE PROBLEM.

Premises: Mr. S., of Eastern Florida, owns a Pine forest of all ages, so that seedlings, saplings, poles, and trees are equally mixed, and estimates that the annual growth is 250 feet, board measure, per acre. The tract is 100,000 acres, and he thus cuts 25,000,000 feet, board measure, annually with the view of not decreasing the growing

stock. The expense for taxes and the cost of protection from fires, etc., is 5 cents per acre per annum; the value of the stumpage is $1 per thousand feet, board measure. Mr. S. thinks that the quality of the forest will be improved gradually, and expects an increase in productiveness of 1 per cent. annually. He figures, besides, on rising stumpage prices, the rise keeping step with the increase in population ($1\frac{1}{2}$ per cent.). He has a chance to invest money at 5 per cent. in an equally safe manner and wants to sell the forest.

Question: Below what price per acre is it not advisable for Mr. S. to sell?

Points: Mr. S. must figure at 5 per cent. interest, as the equally safe investment promises him 5 per cent. as well.

2. If the productiveness of the forest increases by 1 per cent. per annum, and the stumpage price at $1\frac{1}{2}$ per cent. per annum, the receipts will grow at the rate of $2\frac{1}{2}$ per cent. per annum. In discounting these receipts backwards, we have to figure at 5 per cent. $-2\frac{1}{2}$ per cent. $=2\frac{1}{2}$ per cent.

3. The present value of all annual receipts is

$$\frac{25{,}000}{0.050-0.025}.$$

4. The present value of all expenses (taxes and protection) is $\frac{100{,}000\times 0.05}{0.05}$.

Equation: $\frac{25{,}000}{0.050-0.025}-\frac{100{,}000+0.05}{0.05}=x.$

Result: **$900,000 for the whole forest, or $9 per acre.**

27. A YELLOW POPLAR PROBLEM.

Premises: Pisgah forest contains 40,000 acres, stocked with 60,000,000 feet, board measure, yellow Poplar of superior quality, worth now $3.50 per thousand feet, board measure. The owner expects that the prices of Yellow Poplar stumpage will double within the next 15 years (increase of 5 per cent. per annum), and that then small logs and defective logs will have a value as well, so that 70,000,000 feet, board measure, will be available in the year 1915.

The taxes and the general expenses take 6 cents per acre per annum.

The value of the soil, after the timber is cut, can be assumed to be $2 per acre.

The owner figures at 6 per cent. interest.

Question: What is the profit from the investment, if any, at the end of the next fifteen years, aside from the interest of 6 per cent.?

Points: 1. The present value of the investment is $\$60{,}000\times 3.50$ for the trees and $\$40{,}000\times 2.00$ for the soil.

2. The value of the forest in 1915 is $\$70{,}000\times 7.00$ for the trees and $\$40{,}000\times 2.00$ for the soil.

3. The running expenses from 1900 to 1915 are, per annum, $\$0.06\times 40{,}000$. They accumulate, up to 1915, to the sum

$$\frac{0.06\times 40{,}000(1.06^{15}-1)}{0.06}.$$

Equation: $x=70{,}000\times 7.00+40{,}000\times 2.00-1.06^{15}$

$$(60{,}000\times 3.50+40{,}000\times 2.00)\frac{0.06\times 40{,}000(1.06^{15}-1)}{0.06}$$

Result: The owner will find himself $182,000 short. He will lack a good deal of making 6 per cent. on his

investment. As a matter of fact, he will make about 4 per cent. on the investment, and no more, unless the stumpage prices do more than double within the next fifteen years.

28. AN ADIRONDACK PROBLEM.

Premises: A tract of land in the Adirondacks, acquired in the year 1876 at \$5 per acre, was cut over in 1888, yielding then 1,800 feet per acre, board measure, White Pine, worth \$3 per thousand feet, board measure, and 2,600 feet, board measure, Spruce, worth \$1 per thousand feet, board measure.

In the year 1896 there were cut, per acre, another 6,550 feet, board measure, of Spruce, worth \$1.50 per thousand feet, board measure.

The taxes on the forest were 5 cents per acre per annum, the expense of administration and protection 2 cents per acre per annum. Figure at 6 per cent.

Question: At what cost were those last 6,550 feet, board measure, produced?

Points: 1. The price paid for the land, in 1876, was \$5 per acre, which accrued, at compound interest, and up to the year 1896, to $\$5.00 \times 1.06^{20}$.

2. The running expenses during the period 1876 to 1896 were 7 cents per acre per annum, and sum up to the amount of

$$\frac{0.07(1.06^{20}-1)}{0.06}.$$

3. The yield made in 1888 was $\$3.00 \times 1.8 + \$1.00 \times 2.6 = \$8.00$. Discounted forward to the year of calculation, 1896, this yield (which is of course to be subtracted from the various outlays) amounts to $\$8.00 \times 1.06^{8}$.

Equation: $x = 5 \times 1.06^{20} + \frac{0.07(1.06^{20}-1)}{0.06} - 8 \times 1.06^{8}$.

Result: The cost of producing those 6,550 feet was \$5.80. As the value of the 6,550 feet is \$9.82, the owner has gained, aside from making 6 per cent. interest on the investment and aside from having the value of the culled forest for an additional asset, about \$4 per acre.

29. A SPRUCE PROBLEM.

Premises: A lumberman owns 20,000 acres of Spruce land, from which he has just cut 6,000 feet, board measure, per acre, 12 inches and over in diameter at the stump, worth \$1.50 per thousand. After another 20 years he will be able to obtain 3,320 feet per acre, cutting again, down to a 12-inch diameter, and we may expect that after 40 years the same yield will be obtained, and so on.

The land, when cleared, is said to have some value for pasture purposes. The taxes are 4 cents; the expense for administration, protection, etc., 8 cents per acre per annum. Figure at 6 per cent.

Question: What is the forest worth at the present moment?

Points: 1. After 20, 40, 60 (and so on) years, a yield of 3,320 feet, board measure, worth \$4.98 per thousand feet, can be obtained.

2. The necessary expenses are 4 cents plus 8 cents per acre per annum.

3. The value of a forest, like the value of a house or a farm or a business, is equal to the present value of all returns, minus all expenses, expected from it.

Equation : $x = \frac{4.98}{1.06^{20}-1} - \frac{0.12}{0.06} = 2.22 - 2.00$.

Result: The forest, after lumbering, is worth 22 cents per acre. If the owner can sell it, for farming purposes,

at over 22 cents per acre, he should certainly do it, provided that he can make, by reinvesting the proceeds of the sale, 6 per cent. in an equally safe manner.

If the taxes, or the expense necessary for administration, protection, etc., are 2 cents higher per acre per annum than is supposed in the premises, the owner had better give up the land after the first cutting, unless he can sell it, for in that case its forestry value is negative, the necessary expenses devouring all possible profits.

If, on the other hand, there is a good chance for the stumpage prices to rise, say at the average rate of 2 per cent. per annum, the cut-over forest has a value of

$$\frac{4.98}{1.04^{20}-1}-\frac{0.12}{0.06}=\$2.15 \text{ per acre.}$$

The study of future prices of stumpage is of the very greatest importance for the wood owner.

30. A WHITE PINE PROBLEM.

Premises: A Minnesota lumberman owns 10,000 acres of White Pine forest, containing 6,000 feet, board measure, per acre, worth \$3 per thousand. The agricultural value of the land is \$5 per acre, when the timber is removed. Under conservative lumbering, an annual production of 300 feet, board measure, per acre can be expected. Taxes, 8 cents per acre per annum, and protection from fire, under forestry, 12 cents per acre per annum. Extra logging expenses, under forestry, \$4 per acre, at the first cutting. Lumber prices expected to double in 35 years (=annual rise of 2 per cent.). Proper growing stock for forestry 2,000 feet, board measure, per acre.

Question: What interest on the investment will forestry yield?

Points: 1. The investment, to begin with, is 6,000 feet,

board measure, worth \$3 = \$18 per acre plus value of soil, worth \$5 per acre.

2. The yield under forestry is 4,000 feet, worth \$3 = \$12 per acre to be derived at once, and 300 feet, worth 90 cents, to be derived annually thereafter, being the annual production of the 2,000 feet left standing, per acre. The future yields are to be discounted at (x per cent. -2 per cent.).

3. The annual expenses, under forestry, are 20 cents. The extraordinary expenses are \$4 per acre, spent at the first cutting.

Equation: $18 + 5 = 12 + \frac{.90}{0.0\,x - 0.02} - \frac{.20}{0.0\,x} - 4.$

Result: About 7 per cent.

CHAPTER XII.

THE USES OF WOOD.

Wood Serves so Many Purposes and enters so largely into human activities that it may be said to be the most useful of all natural products, excepting only food. Iron is looked upon as the most useful of metals. Wood is not a metal, but in its usefulness it may be placed above iron, which it is replacing in many cases where the latter formerly was exclusively used. Iron and wood have displaced and replaced each other in public favor time and time again, so that their respective claims to supremacy have not yet been decided. For instance, in the manufacture of bicycles, wood rims were first used, and then gave way to iron and steel on account of their lighter appearance and strength. Now, with better methods of construction, wood is again in use, and giving general satisfaction. However, each has its place, and the two often work to better advantage in combination. Experiments have shown that in tensile strength hickory exceeds iron and steel of the same length and weight, and hickory and long-leaf pine resist greater endwise compression than wrought iron. The elasticity of wood enables it to yield to greater stress than metals without receiving permanent distortion, and in like manner it will resist high temperatures without warping, holding its shape until consumed or broken down by mere weight.

In Comparison with Iron, Wood is lighter, easier to work and handle, at present cheaper, and in many cases

stronger and more durable. These facts, coupled with its abundance and ready adaptability, have brought it into such extensive use that the future depletion of the supply has become a matter of some concern to thoughtful people. Even now, in many parts, the local supply has already been exhausted (due much to extravagance and carelessness), and the inhabitants are dependent upon other regions to furnish their wood material, at an increased cost. Treeless regions formerly uninhabited are now teeming with thriving, industrious populations, whose standard of living demands the consumption of large quantities of wood, drawn from limited forest areas. The present supply is rapidly disappearing.

To give the reader a comprehensive view of the manifold utility of wood, and to impress upon him the importance of maintaining a permanent source of supply of this essential material, we may group its uses into general classes, as an enumeration in detail would be too bulky for this volume, and, by sheer weight, fail of its purpose. In a general way, wood is thought of as useful for lumber and fuel. As firewood it heats our houses, cooks our meals, makes steam for driving the engines which run our flour mills, factories, light and power plants, street cars, laundries, etc. Different woods have their own fuel value, as indicated in another chapter; the supply of different kinds varies in localities; the price varies; so that we cannot say that one kind should be used more than another. Poor material must often be taken where no other is available. In Minnesota there is in the wooded regions a considerable variety of fuel woods. The most common are, for the hard woods (or, more properly speaking, broad-leaved trees), Maple, Oak, Elm, Ash, Aspen, Birch, Cottonwood, and Basswood; and of the conifers (or narrow-leaved trees), Pine, Tamarack, Spruce, and Balsam Fir.

As lumber, we may convert wood into a yet more exten-

sive variety of channels of usefulness, included under the heads of general building, construction, and wood working.

In Carpentry, rough material is used in framework, as sills, studding, plates, joists, rafters; in sheathing, roofing, shingles, laths; while finished lumber is put into siding, floors, doors, window frames, and sash, blinds, stairways, stationary furniture, and fixtures, columns, mouldings, turned and carved work (solid and veneer). All kinds of wood are used for this work, according to the purpose and the taste of the builder, but Pine in larger quantities than any other, on account of its cheapness, ease of working, and general utility.

For Railways, wharves, piers, bridges, piling, etc., heavy material is used; that is, large pieces. For railroad ties, bridges, pavements, and culverts all kinds of wood may be used, but those best adapted to withstand the usage of the position are most desired.

In Shipbuilding, ribs, rib frames, keels, and outside planking, take Oak or other hard wood, with trenails of Locust; while for outside planking Pine is used, and interiors and decks are finished to taste and usage with any wood.

In Joinery, which includes furniture making, cabinet and box work, packing cases, and crates, all kinds of wood are utilized.

In the Making of Cars, wagons, and carriages the framework is usually of Oak and Ash, with covering of Pine and fancy woods, while the running gear takes Hickory, Oak, Elm, Ash, Locust—butt cuts being especially valuable.

In Cooperage, barrels, casks, tubs, kegs, pails, churns, and tanks (staves, heads, and hoops) are made of every description of wood, but for vessels designed to hold the finer grades of wet goods, as liquors and wines, White Oak only is desired.

In the Manufacture of Farm and Household Machinery and implements, mostly hard woods of tough, durable qualities, as Oak, Ash, Hickory, and Elm, are in demand. For woodenware (turned, carved, and split-ware goods), again, all kinds of wood find a place. For baskets and wickerware, Willows and other pliable growths are used, while sounding boards of pianos and organs are almost always of spruce. In machine building, cogs, gears, and pulleys are often made of hard wood, while frames of a stationary nature are of Pine.

Timber for Mining Purposes is in great demand in all mining regions, and enormous quantities of it are required, so that the mines are among the largest consumers. In this state some of the deep mines use as much as eighty miles of log timber per year, besides lagging. In mining, usually, the wood of the district is used for props, lagging, etc. The same may be said of fencing—the most convenient wood is taken.

Telegraph Poles require sticks that are free from large knots, and which are durable in contact with the ground. Cedar is much used for this purpose. Flagstaffs and masts call for long, slender, yet resistant, material.

In Lumbering, a considerable quantity of timber is used in roads, skidways, booms, piling, etc., and a much larger quantity of the skidway and roadway material than is necessary is left to rot on the ground after a season's work is ended.

Wood Pulp and Distillation Products. One of the most important industries connected with forests is their use for paper pulp. For this purpose all kinds of wood may be used, but, on account of its superior quality and the ease of working, little is used in this country at present besides Spruce. Many experiments have been made with Poplar, and it also is used to some extent, but Spruce is very much preferred on account of its better fibre. Paper

pulp is made in two ways: First, chemical; second, mechanical. Chemical pulp is made by treating the tissues of the wood with chemicals which dissolve out the lignin substances until only the cellulose or pulp is left. There are several processes used, one of which is by boiling the wood in Glauber salts for seven hours, after which the pulp is washed clean and bleached with chloride of lime until quite white. This process is more expensive than the sulphite process, in which sulphurous acid is used, but is said to give a better product. All kinds of wood may be converted into chemical pulp, but very dark colored and very resinous kinds are usually avoided. Ordinary paper pulp is made by grinding Spruce wood on large stones, against which it is pressed by hydraulic power. For the manufacture of very tough paper and of leather board it is customary to boil the wood a long time before it is ground. Wood that is cooked a long time before grinding makes a dark colored but very tough product. In the manufacture of ordinary printing paper, the wood is put at once upon the stone, and the pulp from it is rolled into paper. It is customary to mix a certain per cent. of chemically prepared paper pulp with ordinary wood pulp in order to improve its strength. Wood pulp is not only manufactured into paper, but boards, buckets, car wheels, and a thousand other things, are made from it. Its use is almost unlimited.

By the Destructive Distillation of Wood (all kinds of wood, all sizes—logs, refuse, sawdust) we obtain charcoal, vinegar, alcohol, creosote, gas, tar; pyroligneous, oxalic, acetic, and other acids; acetone, paraffin, naphthalin; lampblack and other products. From the bark of Oak, Hemlock, Chestnut, and other trees the tannic acid used in tanning leather is obtained.

As we have digressed slightly by including bark under the term "wood," we may go further, and take in also

the sap from which is obtained turpentine, resin, gums, and rubber, sugar, liquors, medicines; the pith, which gives us food and fibre for clothing and other purposes; the fruit and leaves, which are also used for food, medicinal and chemical extracts.

Wood is Made Up of Cells which vary in form and in arrangement in different species. The cells are arranged in the form of irregular, concentric cones, so that a cross section of a tree shows a series of concentric rings. For ordinary purposes, however, a log may be considered as being made up of a series of concentric cylinders, each cylinder representing one year's growth. If each ring is examined closely, it will be noticed that it is made up of an inner, softer, lighter-colored portion, and an outer portion that is firmer and darker colored. The inner portion was formed in the early part of the season, when growth was rapid; this portion is termed the spring wood. The outer portion, where the cells are packed firmly together, grew in the summer, when the growth was slow, and this is termed the summer wood. Since the latter portion is very heavy and firm, it to a large extent determines the weight and strength of the wood.

Wood a Structure. On account of the peculiar arrangement in its structure, wood should not be regarded as a homogeneous mass, but rather as a mechanical structure, the arrangements of the units of which in each case should be carefully considered in estimating its strength and its value for various purposes.

Methods of Sawing. In sawing wood the relation of the saw cut to the annual rings is an important matter, and its reference in relation to them has given rise to the names cross-cut, tangential, and quarter-sawing.

Cross-cut Sawing simply refers to cutting across the grain. This method of sawing is seldom adopted other than for purposes of division, but occasionally it is used

for making thin veneers, which are used in finishing panels and the like.

"Through and Through," bastard or regular sawing, refers to the ordinary way of sawing lumber, in which most of the cuts are tangential to the annual rings.

Quarter-Sawing is sawing that is done perpendicularly to the annual rings of the wood. Wood thus sawed presents an evenness of grain not to be found in wood tangentially sawed. When cut nearly or quite on the radius the beautiful silver grain of some woods is thus shown to the best advantage.

Quarter-sawed lumber presents a more durable surface, and warps and shrinks less than that tangentially sawed.

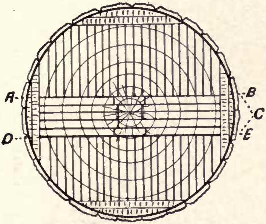

Fig. 68.

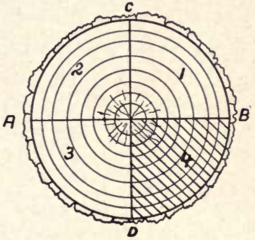

Fig. 69.

Fig. 68.—Common method of quarter-sawing Yellow Pine for flooring.

Fig. 69.—Showing method of quarter-sawing to bring out the figure of the wood to best advantage. The log is first quartered, 1, 2, 3, and 4, and each quarter is sawed as indicated by lines in 4.

If these points alone are the chief considerations, any wood is considered quarter-sawed that presents the edge of its annual rings to its surface at an angle of not less than forty-five degrees. This is done in various ways.

Figure 61 illustrates one method of quarter-sawing such woods as Yellow Pine, which are so sawed solely to increase their strength and wearing qualities. Slabs are taken off

the four sides, then a cant A B is removed by cutting to within two or three inches of the heart. This cant is thrown back on the deck. Then the mill goes on sawing right through the heart C, taking off four to six boards, as the case may be, which are run through the edger and have the heart cut out. This leaves two cants of the same thickness. The one on the deck A B is put back on top of the one D E on the carriage and both are cut up together. Practically all of the stock thus made, except the boards taken off in slabbing, is edged grained, and if oak about half of it would show a fair figure.

If Quarter-Sawing is Done for the Purpose of Bringing Out the Silver Grain of the wood, as is necessary in the case of White Oak for best effects, then the saw cut should always be made towards the heart and on the line of the silver rays. This is a much more wasteful process than the former method, and requires very different management. The more nearly perfect the quarter-sawing is done the more waste there is, and so it is the object of practical men to avoid the extremes of perfect quarter-sawing (at great expense in labor and material) and through-and-through sawing (which is cheapest and most economical of material). In ordinary quarter-sawing of this kind, there is a waste of twenty to thirty per cent. in material as compared with through-and-through sawing. This waste is found in the feather-edged pieces and bevelled edges which have to be cut off, and in the very narrow strips of no value. Small logs waste much more than large logs in quarter-sawing. Most sawyers place the minimum-sized log that should be used for quarter-sawing at twenty-six inches in diameter. It is very important to have quarter-sawed lumber wide, as narrow stock is of comparatively little value. In ordinary sawing, there are always a few cuts made parallel to the silver rays which have the desired quarter-sawed figure.

In practice, several methods of sawing are used to bring out the silver grain. The most common is to quarter the logs, and then saw each quarter, as shown by the lines in Figure 69.

FUEL VALUE OF WOODS.*

"**The Relative Fuel Values** here given are obtained by deducting the percentage of ash from the specific gravity, and are based on the hypothesis that the real value of the combustible material in all woods is the same.

"It appears from Mr. Sharples' experiments that resinous woods give upwards of twelve per cent. more heat from equal weights burned than non-resinous woods; the heat produced by burning a kilogram of dry non-resinous wood being about 4,000 units, while the heat produced by burning a kilogram of dry resinous wood is about 4,500 units, a unit being the quantity of heat required to raise one kilogram of water one degree centigrade.

"Count Rumford first propounded the theory that the value of equal weights of wood for fuel was the same, without reference to specific distinctions; that is, that a pound of wood, whatever the variety, would always produce the same amount of heat. Marcus Bull, experimenting in 1826 upon the fuel value of different woods, found a variation of only eleven per cent. between the different species tested. Rumford's theory must be regarded as nearly correct, if woods are separated into resinous and non-resinous classes. The specific gravity gives a direct means of comparing heat values of equal volumes of wood of different resinous and non-resinous

* This article on the fuel value of woods is taken from the "Report of the Tenth Census," by Prof. C. S. Sargent.

species. In burning wood, however, various circumstances affect its value; few fire places are constructed to fully utilize the fuel value of resinous woods, and carbon escapes unconsumed in the form of smoke. Pine, therefore, which although capable of yielding more heat * than Oak or Hickory, may in practice yield considerably less, the Pine losing both carbon and hydrogen in the form of smoke, while Hickory or Oak, burning with a smokeless flame, is practically entirely consumed. The ash in a wood, being non-combustible, influences its fuel value in proportion to its amount. The state of dryness of wood also has much influence upon its fuel value, though to a less degree than is generally supposed. The water in green wood prevents its rapid combustion, evaporation reducing the temperature below the point of ignition. Green wood may often contain as much as fifty per cent. of water, and this water must evaporate during combustion; but as half a kilogram of ordinary wood will give 2,000 units of heat, while half a kilogram of water requires only 268.5 units to evaporate it, 1,731.5 units remain available for generating heat in wood containing even a maximum amount of water.

"A factor in the general value of wood as fuel is the ease with which it can be seasoned; Beech, for example, a very dense wood of high fuel value when dried, is generally considered of little value as fuel, on account of the rapidity with which it decays when cut and the consequent loss of carbon by decomposition."

* From a given weight.

TABLE OF FUEL VALUES OF OUR DIFFERENT WOODS.

Botanical Names.	Common Names.	Approximate relative fuel value.	Weight of a cu. ft. of absolutely dry wood
			Lbs.
Abies amabilis	Amabilis Fir	42.18	26.35
Abies balsamea	Balsam Fir	38.02	23.80
Abies concolor	White Fir	36.07	22.67
Abies grandis	Lowland Fir	35.08	22.09
Abies magnifica	Red Fir	46.87	29.30
Abies nobilis	Noble Fir	45.46	28.42
Acer macrophyllum	Oregon Maple	48.83	30.59
Acer negundo	Box-elder	42.82	26.97
Acer rubrum	Red Maple	61.65	38.5
Acer saccharinum	Silver Maple	52.52	32.84
Acer saccharum	Sugar Maple	68.75	43.08
Aesculus glabra	Ohio Buckeye	45.03	28.31
Aesculus octandra	Yellow Buckeye		26.64
Betula lenta	Sweet Birch	75.97	47.47
Betula lutea	Yellow Birch	65.34	40.81
Betula nigra	River Birch	57.42	35.91
Betula papyrifera	Paper Birch	59.40	37.11
Betula populifolia	White Birch	57.43	35.90
Carpinus caroliniana	Blue Beech	72.26	45.41
Castanea dentata	Chestnut	44.95	28.07
Castanea pumila	Chinquapin	58.80	36.69
Castanopsis chrysophylla	Goldenleaf Chinquapin	55.55	34.74
Catalpa catalpa	Catalpa	44.57	27.88
Catalpa speciosa	Hardy catalpa	41.48	25.96
Celtis occidentalis	Hackberry	72.08	45.41
Chamaecyparis lawsoniana	Port Orford Cedar	46.16	28.80
Chamaecyparis thyoides	White Cedar	33.12	20.70
Diospyros virginiana	Persimmon	78.32	49.28
Fagus atropunicea	Beech	68.48	42.89
Fraxinus americana	White Ash	65.16	40.77
Fraxinus lanceolata	Green Ash	70.71	43.35
Fraxinus nigra	Black Ash	62.72	39.37
Fraxinus oregona	Oregon Ash	57.12	35.72
Fraxinus pennsylvanica	Red Ash	62.35	38.96
Fraxinus quadrangulata	Blue Ash	74.50	44.77
Gleditsia triacanthos	Honey Locust	66.86	42.00
Gymnocladus dioicus	Coffee Tree	68.88	43.21
Hicoria alba	Mocker Nut	81.29	51.21
Hicoria glabra	Pig Nut	81.36	51.21
Hicoria laciniosa	Shellbark Hickory	80.35	50.53
Hicoria minima	Bitternut	74.74	47.06
Hicoria ovata	Shagbark Hickory	83.11	52.17
Hicoria pecan	Pecan	70.99	44.75

TABLE OF FUEL VALUES OF OUR DIFFERENT WOODS—(*Continued*).

Botanical Names.	Common Names.	Approximate relative fuel value.	Weight of a cu. ft. of absolutely dry wood
			Lbs.
Ilex opaca	American Holly	57.74	36.26
Juglans cinerea	Butternut	40.66	25.46
Juglans nigra	Black Walnut	60.91	38.11
Juniperus occidentalis			35.93
Juniperus virginiana	Red Juniper	49.11	30.70
Larix laricina	Tamarack	62.16	38.86
Larix occidentalis	Western Larch	74.00	46.16
Libocedrus decurrens	Incense Cedar	40.14	25.03
Liquidambar styraciflua	Sweet Gum	58.73	36.83
Liriodendron tulipifera	Tulip Tree	42.20	26.36
Magnolia acuminata	Cucumber Tree	46.76	29.23
Magnolia foetida	Magnolia	63.26	39.64
Morus rubra	Red Mulberry	58.56	36.75
Nyssa aquatica	Cotton Gum	51.58	32.37
Nyssa sylvatica	Black Gum	63.66	39.59
Ostrya virginiana	Ironwood	82.42	51.62
Picea canadensis	White Spruce	40.38	25.25
Picea engelmanni	Engelmann Spruce	33.38	21.49
Picea mariana	Black Spruce	45.71	28.57
Picea rubra	Red Spruce		28.13
Picea sitchensis	Sitka Spruce	42.80	26.72
Pinus aristata	Bristol-cone Pine	55.56	34.72
Pinus balfouriana	Foxtail Pine	54.17	33.86
Pinus echinata	Shortleaf Pine	60.86	38.04
Pinus divaricata	Jack Pine	47.50	29.67
Pinus flexilis	Limber Pine	43.42	27.16
Pinus glabra	Spruce Pine	39.13	24.50
Pinus heterophylla	Cuban Pine	74.83	46.76
Pinus jeffreyi	Jeffrey Pine	50.53	32.44
Pinus lanabertiana	Sugar Pine	36.76	2[illegible].96
Pinus monticola	Silver Pine	38.99	24.[illegible]
Pinus murrayana	Lodgepole Pine	40.83	25.53
Pinus palustris	Longleaf Pine	69.82	43.62
Pinus ponderosa	Bull Pine	46.99	29.45
Pinus ponderosa scopulorum	Rock Pine		28.78
Pinus radiata	Monterey Pine	45.60	28.50
Pinus resinosa	Red Pine	48.41	30.25
Pinus rigida	Pitch Pine	51.39	32.10
Pinus strobus	White Pine	38.47	24.02
Pinus taeda	Loblolly Pine	54.27	33.91
Pinus virginiana	Scrub Pine	52.93	33.09
Platanus occidentalis	Sycamore	56.52	35.39

TABLE OF FUEL VALUES OF OUR DIFFERENT WOODS—(*Continued*).

Botanical Names.	Common Names.	Approximate relative fuel value.	Weight of a cu. ft. of absolutely dry wood
			Lbs.
Populus angustifolia	Narrow-leaf Cottonwood	38.81	24 38
Populus balsamifera (*var candicans*).	Balm-of-Gilead	41.42	22.65
Populus deltoides	Cottonwood	38.53	24.24
Populus fremontii	Fremont Cottonwood	48.77	29.71
Populus grandidentata	Largetooth Aspen	46.11	28 87
Populus tremuloides.	Aspen	40.10	25.13
Populus trichocarpa.	Black Cottonwood	37.66	23.77
Prunus serotina	Black Cherry	58.14	36.28
Pseudotsuga taxifolia	Douglas Spruce	51.53	32.14
Quercus acuminata	Chinquapin Oak	86.09	53.63
Quercus alba	White Oak	74.39	46.35
Quercus chrysolepis	Canyon Live Oak	84.43	52.93
Quercus coccinea	Scarlet Oak	73.91	42.20
Quercus densiflora	Tanbark Oak	67.25	42.55
Quercus digitata.	Spanish Oak	69.11	43.17
Quercus lobata	California White Oak	73.87	46.17
Quercus macrocarpa	Bur Oak	74.06	46.45
Quercus michauxii.	Cow Oak	80.03	50.10
Quercus minor	Post Oak	83.01	52.14
Quercus nigra	Water Oak	72.39	45.14
Quercus palustris.	Pin Oak	68.82	43.24
Quercus platanoides	Swamp White Oak	76.18	47.75
Quercus prinus	Chestnut Oak	74.42	46.73
Quercus rubra	Red Oak	65.28	41.25
Quercus velutina	Yellow Oak	70.10	43 90
Quercus virginiana	Live Oak	93.93	59.21
Robinia. pseudacacia	Locust	72.96	45.70
Sequoia sempervirens	Redwood	42.02	26 22
Sequoia washingtoniana	Big Tree	28.67	17 96
Taxodium distichum	Bald Cypress	45.24	28.31
Taxus brevifolia	Pacific Yew	63.78	39.83
Thuja occidentalis	Arborvitæ	31.53	19.72
Thuja plicata	Giant Arborvitæ	37.90	23.66
Tilia americana	Basswood	45.00	28.20
Tilia heterophylla	White Basswood	42.27	26.51
Tsuga canadensis	Hemlock	42.20	26.42
Tsuga mertensiana	Western Hemlock	51.61	32.29
Ulmus alata	Wing Elm	74.17	46.68
Ulmus americana	White Elm	64.54	40.55
Ulmus crassifolia	Cedar Elm	71.59	45.15
Ulmus pubescens	Slippery Elm	69.77	43.35
Ulmus racemosa	Cork Elm	72.20	45.63

CHAPTER XIII.

DURABILITY OF WOOD.

Decay in Wood is due to the breaking down of the tissues by fungi. In some cases the fungus destroys the woody cells; in others it uses up the starch found in the cells and merely leaves a blue stain (bluing of lumber). Some kinds of fungi attack only conifers, others only hard woods; some are confined to one species while others may affect several species, but probably no one of them attacks all kinds of wood Fig. 63 shows the discoloration of wood by a shelf fungus The wood contains the fungus plant, which, when ready to produce its spores, sends out a shelf-like body on the side of the wood. These shelves contain the spores and may be found on many old decayed trees or stumps.

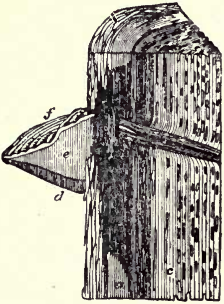

FIG. 70.—"Shelf" fungus on the stem of a pine (Hartig). *a*, Sound wood; *b*, resinous wood; *c*, partly decayed wood or punk; *d*, layer of living spore tubes; *e*, old spore tubes filled up; *f*, fluted upper surface of the fruiting body of the fungus which gets its food through a great number of fine threads (the mycelium), its vegetative tissues penetrating the wood and causing it to decay.

Various odors are produced in the wood by some of

these fungi; they may be pleasant, as those found sometimes in the Oak, or unpleasant as those infesting some of the Poplars. By studying both the favorable and the unfavorable conditions for the growth of the rot-producing fungi, we may learn the best methods of increasing the durability of our woods, and thus avoid unnecessary waste.

The soil and conditions under which wood is grown affects its durability. Coniferous woods with narrow, annual rings are most durable, especially when grown on comparatively poor soils, in dense forests, and at high altitudes. On the contrary, the hard woods with wide annual rings are most durable, and are grown on the low lands and in isolated positions. The wood of most broad-leafed trees produced in the open is more durable than that from the dense forest.

Sound Mature Trees Yield More Durable Timber than either young or very old trees. A tree is considered mature when it ceases growing vigorously, which condition is indicated by the flattening out of the crown, by dead branches in the crown, and by changes in the color of the bark. It is not indicated by size, since this varies in the same species according to circumstances. A small tree poorly situated for growth may be as old or older than a larger tree growing under better conditions.

Intense Coloration of the Heartwood is a measure of durability in timber, and faintly colored heartwood resembles sapwood in its properties, only surpassing it in dryness. The tannin or coloring matter of heartwood is antiseptic. Where heartwood does not change its color or is lighter than the sapwood the protecting substances are generally absent, and the wood is therefore liable to decay. This is plainly shown in the hollow trunks of Willow and Basswood.

Sapwood Contains More Ready-Made Food in forms acceptable to a greater number of kinds of fungi than the heartwood. This largely accounts for the fact that sapwood is much more liable to decay than heartwood. This is especially true in the case of Cedar and Pine, where the heartwood is protected by resinous substances. But when the sapwood is well seasoned and heavier than the heartwood it lasts as long. Wood that has been once attacked by fungi becomes predisposed to further decay.

The Time of Cutting Timber affects its durability only as the weather at the time of cutting affects the curing process. Wood cut in summer is generally affected by decay-producing fungi, rapid fermenting of sap, and by bad checking, owing to very rapid curing on the outside. As the cracks thus made go deep into the wood they may increase the danger from fungi. Where summer-felled wood is worked up at once and protected by kiln-drying, it lasts as long as that cut at any other season.

Early winter is probably the best time to cut timber, as regards durability, since it then seasons slowly at a time when the rot-producing fungi are not active, so that it can cure over on the outside before summer. Many kinds of fungi and beetles find a very favorable place just under the bark of logs. These can be avoided, the curing of the timber hastened, and its durability greatly increased, by removing the bark soon after felling. When trees are cut in full leaf it is advantageous to let them lie at full length until the leaves are thoroughly wilted (two or three weeks) before cutting to size. With conifers this is a good practice at any season, and while not practical, yet theoretically all winter-cut trees should be left to leaf out in the spring before being worked. In this way most of the sap is evaporated, but in the care of timber

that is to go at once into the water these precautions are not so important.

Heat (60 Degrees to 100 Degrees Fahr.), Moisture and Air in moderate quantities produce conditions under which wood quickly decays. It is on this account that fence posts rot off near the surface of the ground, where about such conditions of heat and moisture are usually found during several months of the year. For the same reason what is known as **dry rot** destroys green floor joists or other timbers where they are tightly enclosed, as under a house without ventilation, since moisture is always present in such places, and the timber cannot dry out. Perfectly dry wood or that submerged in water will last indefinitely, and there seems to be no difference in different kinds of wood under these conditions. Pieces of pine wood in good condition have been found in Illinois, buried to a depth of sixty feet, that must have been there for many centuries. Nearly sound pine logs are occasionally found in the woods of this State, where they have a thick moss covering that has kept them moist and prevented their decay for hundreds of years. The remains of timbers in the piles of the lake dwellers in Switzerland, which must have stood in place two thousand years, are still intact. In these instances the wood was kept moist, and never came in contact with the air. It is very evident, too, that wood which is kept in a dry place does not decay, since it may be found in an unimpaired state of preservation in some of our very oldest buildings.

In the following table is shown approximately the time fence posts will last in Minnesota. This table is based on practical experience in that State:

TABLE SHOWING RANGE OF DURABILITY OF FENCE-POSTS IN MINNESOTA. (Air dry)

Red Cedar	30 years
White Cedar (quartered 6-inch face)	10–15 years
White Oak (6-inch round)	8 years
Red and Black Oak	4 years
Tamarack (Redwood)	9 years
Elm	6–7 years
Ash, Beech, Maple	4 years
Black Walnut	7–10 years
White Willow, 6 inches in diameter, peeled and dried	6–7 years
Catalpa	20 years

Curing is one of the most important processes in its effect on the durability of wood. Well cured wood resists decay far better than fresh wood, because it contains an insufficient amount of water for the growth of fungi. Green wood covered with paint before it is dry is often destroyed by dry rot, since this fungus finds abundant moisture under the paint, and the protection which was intended for the wood really protects its enemy, the fungus. Paint and other wood-protecting compounds are efficient only when they are applied to dry material, which they preserve by protecting them from moisture. But fence posts or other timber to be used in moist places, if well cured, will, even if not protected, last much longer than fresh cut timber. The amount of moisture in wood, then, is the most important factor in influencing its durability.

Timber is Best Cured Under Cover, where it is protected from the sun and the full force of the wind, but has a good circulation of air. If piled in the open, it is a good plan to shade it. When piling green or wet timber, place lath or other strips of wood of uniform size under each log, post or tie. In piling sawed lumber the lath should be placed at the ends, as in this position they in a measure prevent checking on the ends.

From twelve to eighteen months is generally sufficient to cure wood for ordinary use, while for special work ten or more years may occasionally be required. If green or wet timber is closely piled in warm weather it is likely to rot. The best method of curing timber without resorting to the use of expensive apparatus is to work it up at once and soak it in water for from one to three weeks, to remove the sap from the outside of the wood. It will then season more quickly and be more durable than when dried without soaking. Sometimes it is absolutely necessary to thus water season large timbers, as it is impossible to get the sap out of them by atmospheric seasoning. Large checks or cracks in the ends of logs or other timber of large dimension may be avoided or greatly lessened by painting the ends with linseed oil mixed with ground charcoal or other material, to give it consistency. Covering with cloth or tarred paper also lessens checking.

Good Coatings for Wood consist of oily or resinous substances that are easily applied in a smooth coat and dry readily, yet do not have any tendency to crack or peel off. They should be applied to the whole exposed surface.

Coal Tar is one of the best materials for covering wood to increase its durability. It is best applied hot, especially if mixed with oil of turpentine, as it then penetrates more deeply. A mixture of three parts coal tar and one part unsalted grease, to prevent the tar from drying too quickly so it may penetrate the wood better, is recommended. One barrel of coal tar will cover from two to three hundred posts if it is properly applied.

Oil Paints are next in value. Boiled linseed oil is used with lead, pulverized charcoal, or other similar material, to give it substance. Soaking the dry wood in crude petroleum is also recommended.

Lime Whitewash is a good preventive of decay in

wood, and, although not as good for this purpose as coal tar, it is very desirable. As with all other preservatives that are applied to the surface, the wood should be very dry before it is applied, and the wash should be applied evenly over all the exposed parts. It is on account of the lime washing out of the mortar that the shingles on a roof just below the chimney last longer than on other parts of the roof. But if whitewash is to be applied to shingles, it should be applied before they are laid by dipping.

Charring those parts of posts or timbers which come in contact with the ground is a good preventive, provided a thick layer of charcoal is formed and the work so carefully done as not to cause the timber to crack, since deep cracking exposes the interior to decay. If the work is not carefully done the timber may be seriously weakened.

Antiseptics. The impregnating of timber with sulphate of copper (blue stone), sulphate of iron (green copperas), chloride of zinc, creosote, salts of mercury, or other similar material, has the effect, when properly done, of greatly increasing its durability. Such antiseptic substances have the power of destroying the rot-producing fungi. The materials are often applied to fresh logs. If dry timber is to be treated, it is first boiled or steamed to open the cells. A hollow cap connected with a force pump is placed over one end, and the liquid forced through the cap into the wood, which results in forcing out the sap at the opposite end and replacing it with the antiseptic, but the more common method is that described below as the treatment given in impregnating railroad ties in Europe. All the antiseptics mentioned have been used to some extent for this purpose, but for various reasons chloride of zinc is now most generally used. Railroad ties thus treated last much longer than those not so treated. Impregnation also to some extent renders wood fire-proof.

Iron Railroad Ties. A few years ago it was thought probable that iron railroad ties would come into general use in Europe, owing to the scarcity of Oak ties. They have, however, been found to give a very unyielding road bed, and are not generally liked, and are seldom used for more than a short distance at railroad stations. The disposition now is to substitute impregnated Beech ties for iron, and the successful impregnation of this wood, causing it to become quite durable, has had a large effect in doing away with iron ties.

The Impregnation of Beech Wood for railway ties is a large industry in Europe. Without impregnation Beech is one of the least durable of woods, but by modern impregnation methods it can be made to last at least fifteen years in any soil, and it is customary for concerns engaged in this business to warrant the durability of their impregnated ties for twelve years. Pine and Oak ties are not impregnated.

The process commonly followed in many parts of Germany is about as follows: A large boiler-tank is provided, which is about six feet in diameter and forty to one hundred feet long. This is made with heads that can be securely and tightly bolted on. It also has a small track for the cars which carry the ties. Before treatment, the ties are mortised to receive the rail plates. After the tank is filled with cars loaded with ties, the steam is turned on for one to three hours, with a pressure of about twenty-five pounds. This treatment softens the wood and dissolves the sap. The air is then pumped out of the tank, which removes the sap from the ties and leaves a vacuum. When this has been completed and the vacuum made, the impregnating material is added under a pressure of about 120 pounds. This forces the impregnating material into the cells of the wood. The preservative material used is made up one-third of a three per cent. solution of chlo-

ride of zinc and two-thirds of dead oil (creosote oil). Chloride of zinc was formerly used alone, but it was found that it washed out after a few years, where the wood was laid in contact with the ground, and thus the wood was liable to decay; but by the addition of dead oil, which is itself a good antiseptic, the cells of the wood were effectually sealed over and water prevented from entering, and thus the chloride of zinc was protected and the process made more permanent. The cost of this treatment in Hessen, Germany, is estimated at about twenty-two cents per tie. In this country Pine ties are recently reported to have been impregnated in this way for 9 cents per tie.

Among the other processes for the preservation of wood are the following:

Kyanizing Process. In this the ties are steeped in a solution of bichloride of mercury (corrosive sublimate), in the proportion of about one part bichloride to one hundred parts, by weight, of water. The time required for this process is about one whole day for each inch in thickness. This material is an active poison, and must be handled carefully. It has given excellent satisfaction in the preservation of timber which comes in contact with the soil, but soon corrodes metal in contact with it.

Boucherie Process. In this process the timber is impregnated with a one per cent. solution of sulphate of copper, either by pressure in a closed vessel or by applying it to the end of the tie or log and forcing it through. This is an excellent antiseptic, and is said to have doubled the life of the Pine ties in Europe.

Creosoting. This process is very extensively used, and has given excellent satisfaction. The material is what is known as dead oil, of coal tar, and is obtained by distilling coal. Naphthalin is its principal preservative. A similar oil, known as wood creosote oil, is obtained by the distillation of Pine wood, but is said to

be much more soluble than the dead oil, and on this account more liable to wash out of the wood when in contact with the soil.

Zinc Tannin Process. In this process the chloride of zinc is protected from being washed out of the ties by coagulated albumen. The process is as follows: The ties are impregnated with chloride of zinc mixed with a small percentage of dissolved glue. They are then subjected to heavy pressure, after which the solution is drawn off and a tannin solution added at a pressure of 100 pounds. This material combines with the glue, and forms a leathery, waterproof substance which permanently closes the pores or outer cells of the wood, excluding moisture and retaining the zinc.

Burnettizing. In this process the timber is impregnated with chloride of zinc, the operation being similar to that of creosoting. It has a wonderful preservative effect upon the timber, the only objection to it being that the solution is liable to be washed out of the ties. This is overcome in the modern treatment of the ties in Germany by using a certain per cent. of dead oil with it, as previously noted in describing the method of impregnating railroad ties.

Fire-proof Wood. It has been known for many years that wood could be made fire proof by filling it with certain chemicals in much the same way that railway ties are impregnated. The most common chemical used for this purpose was phosphate of ammonia, and it is perhaps the best material for this purpose that has ever been used, but it is so expensive that the use of it is quite impracticable. The next best material that has been used for this purpose is sulphate of ammonia, but like phosphate of ammonia this somewhat injures the flexibility of the fibre and corrodes metal, and in addition deadens the color and causes the wood to be more

hydroscopic. These chemicals, either alone or combined, have given some very good results, but have not been entirely satisfactory. They have been used in fire-proofing warships, where great results have sometimes been realized, as, notably, in the war between China and Japan, where this treatment is said to have given Japan a great advantage in the greatest naval battle of that war. If a fire-proofing process were discovered that combined the merits of cheapness without injuriously affecting the qualities of the wood, it would be much sought after, and its application would be almost endless. In order to be effective such a process must not only be cheap, but must not prevent the wood from holding paint varnish and glue well, nor injure its fiber, nor corrode metal in contact with it nor tools used in working it, neither must it increase its tendency to absorb moisture.

CHAPTER XIV.

FOREST ECONOMICS.

Alarm About Destruction of Forests! For many years the attention of the people of this country has been drawn to the possibility of a depletion of our forests and a timber famine in the near future. But increased transportation facilities have made new sources of timber easily accessible to us, which fact, together with the use of inferior kinds of trees for lumber, has kept the predicted timber famine from materializing, until now our people have become skeptical on this point, and look upon these predictions as very premature. To any one who carefully studies the subject, however, it will be very evident that our supply of White Pine, that most generally useful of all our timber trees, is fast decreasing, and that it cannot be very many years before this will be apparent by the advance of prices for this kind of timber. Most of the land of good quality seems destined to be eventually used for farming purposes, but there will always remain a large area of stony or very sandy or mountainous land that will be unfit for profitable agriculture, and which will produce more revenue when used for the production of timber than when used for any other crop. There is also a large amount of land that will not be needed for farming purposes for many years, and this should grow timber until needed for agriculture. Besides this, with the increased value of fuel, lumber, and other forest products, there will come a better appreciation of the

importance of farm wood lots as a source of fuel, poles lumber, etc., for farm use, and a more general disposition to save some land for this purpose and to properly care for it.

Price of Fuel. At present, in part of the forested area in many of the Western States, the forests are greatly in the way of settlers, and the price of fuel is simply the cost of gathering it, no charge whatever being made for the wood itself. This state of things exists because not only in the forests but more especially in the great area of cut-over timber lands in those sections there is such an immense amount of dead and down timber that it is seriously in the way and far in excess of the fuel demands of the settlers on those lands for a score of years to come. There seems to be something incongruous in the fact that while in Minnesota, for instance, one-half of the State is prairie, and sadly in want of fuel and other forest supplies, the other half has such a superabundance of these products that they are going to waste, and only a small portion is considered worth marketing.

Value of Forest Industries of Minnesota. The marketing of the products of the virgin forest in this country has added greatly to our wealth and prosperity, and under proper management this source of wealth would continue indefinitely. Minnesota furnishes a good example of the conditions in this industry in several of the Western States. The value of the forests of Minnesota is most easily seen by showing the number of men employed. According to the report of the Bureau of Labor, there were employed in logging, in the year 1899–1900, 15,886 men and 8,285 horses. The average time of the men was about twenty weeks. They were employed in 329 camps, and cut 1,112,000,000 feet board measure. The total wages was $2,988,900, besides board, or about $4,180,000, including board.

In the wood-working industries, the following men were employed in the year 1900:

Sash and door manufacturers	1,186
Sawmills, shingle- and lath-mills	9,179
Planing-mills	1,707
Rattan and willow works	48
Paper-mills	229
Lumber-yards	276
Wood-working shops	830
Furniture and fixtures	1,405
Cooperage	772
Box manufacturing	356
Total	15,988

Making a total in the wood-working and lumbering industries, besides carpenters and builders, of 31,874 men employes. The best authorities agree that the normal annual increase on the 12,000,000 acres of forest area in Minnesota should be about 2,000,000,000 feet board measure, or a mean annual increase of 185 feet board measure per acre. If this were true, it would leave a wide margin to the present annual timber cut without impairing the normal growing stock. In other words, this great lumber industry, of so much value to that State, would be continued indefinitely under normal conditions. But there is practically no timber land in that State under normal conditions, and there is little or no increase on the far greater part of her cut-over timber lands. On this account the continuance of the lumber industry is not hoped for, by those engaged in it, there. In other words, they are working their timber resources as though they were a mine which could never be restocked.

The timber lands of all civilized countries have passed through about the same wasteful conditions as those which now prevail here. While this does not justify

the present deplorable situation here, it shows us that the trouble we are suffering from is a common one, that will right itself with increased population and proper education. Previous to 1700 the forests of Germany were in much the same condition as those here at present, and a square mile of forest land could be bought for the present price of one of the oaks planted at that time. Our people

FIG. 71.—Schönmunzack in the Black Forest, Germany, showing a combination of forestry, farming, and manufacturing

are simply uninformed as to the possibilities of our forest land under proper conditions.

Like any Other Business, Forestry Requires Capital. This is partly in land and partly in the growing crops of wood. Capital in wood may often exceed that in land. Income from forests comes as timber, fuel, bark, and in items of smaller importance, such as grazing, fruit, medicinal plants, hunting, etc.

Forests Should be so Managed as to yield an annual increase, as in this way the conditions for most successful

marketing are best met. Under such conditions, too, a certain amount of experienced help can be expected to become located conveniently near, as they will have steady work, while if the products are harvested at irregular intervals new help must be engaged at each harvest, which is extremely undesirable.

In Considering the Returns from the Forest the following terms should be clearly understood: (1) Normal growing stock, (2) normal income, (3) capital stock, and (4) actual income. These are defined in the following paragraphs:

Normal Growing Stock. Since the annual valuable increase of wood is in proportion to the amount of leaf surface on trees of the right kind, size, and form, it follows that there must always be a certain number of trees of a certain size in order to obtain normal annual growth. This material represents invested capital, and the highest annual income is dependent upon having a normal growing stock upon the land. As a matter of fact, this is an ideal thing, and is seldom, if ever, exactly attained. The amount of normal growing stock which there will be upon one acre will depend upon the species, its age and conditions, and must be determined in the working plan of the forest tract after a careful study of its conditions.

The Normal Income is the crop of wood that a given tract of forest will produce per year under normal conditions. This will, of course, vary with the species and conditions. It may be harvested by selecting only the large trees from all over the area, or by cutting clean over a certain portion of it, as shown in chapter X. It is very plain that, if the increase per year is a given amount, it may be harvested by either method without infringing on the normal growing stock of the whole area. For some conditions the selection method is preferred, while for others, such as for even stands of Spruce, which are

liable to blow down when thinned, it might be better to cut clean, and keep the trees in even-age groups. In this latter case the tract should be divided into as many parts as there are years in the rotation, and the timber from one part cut each year. This would mean the planting or seeding of a like amount each year.

Capital Growing Stock. This represents the actual amount of trees on the land which is producing wood growth of value. The nearer this approaches to the normal growing stock the better the condition of the forest and the larger its returns.

Actual Income represents the annual return which a given forest tract is producing.

Increasing Value of Forests. In countries where forestry has reached a high degree of development a piece of land is regarded as being in forest as soon as it is stocked with trees, even if the seedlings are not yet over two inches high and are hardly to be seen at a short distance. Such a piece of land should have increased value and should be regarded as earning a rate of interest. It is so regarded in many of the European states, and money lenders there consider this matter as important when placing a loan; for while the increase on such land cannot be gathered at all for perhaps sixteen or twenty years, and then only a small amount, yet a certain increase in woody tissue is being stored up each year which will later on be harvested. It should be regarded as being worth at any time a certain proportion of its total value at maturity, which perhaps will not come for twenty years, but if a forest is reasonably protected from fire, it is almost as sure to earn a certain increment as that the conditions on the earth will remain as they are for eighty years. And if a forest is twenty years old, it may be in such condition that it would be wasteful to try to derive any income from it for perhaps

[*To face page* 247.]

FIG. 72.—Combination of City Park and Forestry at Heidelberg, Germany.

twenty years more, yet it is worth perhaps one-third of what it will be worth twenty years hence. Thus, if at forty years it will yield ninety cords of paper pulp per acre, worth five dollars per cord, it should at twenty years be worth about $140, after allowing for compound interest at six per cent.

Unproductive Forest Land. In almost every range of forest there will be some land that is quite unproductive. This will generally consist of ledgy land, or that which is elevated above the tree line, or perhaps may consist of extended swamps. But on this account it should not be thought worthless, but should be allowed to produce what growth it can, especially where it is valuable in protecting the sources of streams, and in the case of elevated mountain sides the scrubby growth of no value for timber may be very valuable in preventing land slips or snow slides. Of course, in the case of individuals having small holdings such considerations do not apply, but they are important and should be encouraged in any comprehensive forestry scheme.

European Systems of Forest Management have been frequently referred to as being applicable to our conditions, but, while we can learn much of value from the history and practice of European forest administration, our conditions are so very different from those existing in Europe that much discretion must be exercised in adapting their methods to our conditions. The chief difference between their conditions and ours is in the higher price of their timber and their cheaper hand labor, which makes practicable there very different methods than could be profitably used here. The conditions in the remote parts of Russia are more like those in this country than are, perhaps, to be found elsewhere in Europe, and there is still in those sections a great waste of forest products, and large losses occur there annually from forest

fires. But in the most accessible parts of Russia, and in Sweden, Norway, and in the larger portion of Germany and France, there is a profitable market for all we term waste forest products, such as the smaller top logs, the branches, twigs, leaves, stumps, underbrush, and even the roots of trees. In this country such material encumbers the ground, and greatly increases the danger of forest fires, which is by far the greatest source of injury to growing timber.

Taxes on Timber Lands. The taxes on timber lands are generally excessive in this country, and entirely out of proportion to the value of the land, and it is largely on this account that owners of timber lands do not care to hold them. This, as a matter of State policy, is unwise, for the reason that it prevents the development of economic forestry. In most European countries where forestry is well developed it is customary to levy a small tax on the land and to tax the products only when they are harvested. Such a tax system is almost unknown in this country, but it is much more just for forest property than our ordinary taxing methods. It would seem that forest property ought to be regarded in a special class for the purposes of taxation, for the reason that as a matter of State policy it should be encouraged, and the ordinary methods of taxation retard its best development.

Income from Game Preserves. Most of the European forests are used as game preserves, as well as for forestry purposes. It is well known, however, that the presence of large game in the forest is generally a great disadvantage, and that much injury may come from its presence there, and the rental of about twenty-five cents per acre, which is the price generally paid for the use of forest preserves, is not sufficient to cover the loss.

The German forestry service generally think it desira-

[*To face page* 249.]

Fig. 73.—Scene in the Black Forest near Oberthal, Germany, near a Popular Resort.

ble to have game in the forests for other considerations than that of its rental value, and chiefly from the fact that it adds interest to the forest, and in this way attracts the attention of parties who otherwise would not be so much interested in it. There is a great deal of sentiment attached to the presence of this game among the foresters themselves, and it is said that were it not for this sentiment, Germany could never keep as fine a body of men in its forestry service as it now has. In the renting of land as a game preserve, it is customary to limit the number of deer, etc., that shall be killed in any one season. It is customary to make an estimate of the game of the forest ranges each year. In the case of deer this is done by feeding them in paddocks during the winter.

Government Supervision of Forests in Germany. It is the policy of the government in most of the German provinces not to interfere more than is necessary in the management of private woodlands, although the custom varies in the different provinces. On this account, where the land is not much broken, there are few requirements in regard to maintaining forests; but where the land is much broken, as is the case in the Bavarian Alps and the Black Forest, it is sometimes customary to require private owners to deposit the cost of replanting their land when they cut their timber, and if they do not attend to the replanting within a certain period it is done by the government. It is the very general settled policy of the provincial governments to keep in forest about the same area that is now devoted to this purpose, and since the water powers in the valleys are dependent for the regularity of their supply upon the forests that are upon the mountain sides, the government reasons that the exercise of some supervision in this matter is necessary for the well-being of all. Where forests are owned by municipalities, the municipal authorities can generally hire their

own superintendent; but in some provinces the government generally manages to have laws passed that will make it most convenient for municipalities to employ the government superintendent. In the case of municipal forests the governments generally allow the cutting of only the increase each year. If this matter was left entirely to the will of the people, they would frequently sacrifice the future for present gains. This supervision may be likened very much to that which is exercised in many States in preventing cities and towns from acquiring an indebtedness beyond a certain percentage of their taxable valuation. However, in case there is a pressing need for some public improvement, as for instance a schoolhouse, the government may allow extra cuttings for this special purpose, but in after years the annual cuttings must be lessened until the capital growing stock of wood on the land is made good.

Forest Reservations and National Parks. Many of the forest reservations in this country are in need of immediate attention. Much of the virgin timber on them has passed its prime and is decaying, and the constant liability to forest fires makes the young growth very unsafe. The increased demand for timber and the high price for the same has encouraged lumbermen in trying to have the timber on such reservations thrown onto the market. When cut in the ordinary manner, there is practically nothing left, and the end of the tree growth is reached. If this were to be managed in a proper way, the mature trees would be cut as soon as there was a demand for lumber, and those trees should be left which are still growing thriftily. In some cases, there is talk of utilizing some of these reservations as national parks, and in America too often the park idea means simply a piece of land from which nothing is removed. The best plan for managing these large tracts of timber would

probably be to use them as examples of good forestry, as well as for parks, as the one purpose need not in the least interfere with the other. It is quite customary in many parts of Europe to have woodland resorts carried on in this way. The carrying out of such a plan means practically the establishment of a business, which at the outset will employ a large number of men in harvesting the mature trees, which will generally be from one-third to one-half of that which is standing. This business, however, will not cease to be productive when the mature trees are cut, but will go on indefinitely producing a certain amount of annual growth which can be harvested. Putting a reservation onto this basis would have the effect of building up the country permanently, and would undoubtedly lead to the establishment of summer resorts in the most favored localities in them, which would also add to their prosperity. The government can well afford to do this, owing to the fact that it is perpetual and pays no taxes, while perhaps it would be extremely unwise for individuals to engage in such an enterprise, owing to the fact that taxes are too high and the profits are too long delayed. On many of the Indian reservations such an arrangement as this would result in great benefit to the tribes located there, for it would assure them in the continuance of their reservations as homes, and at the same time bring them in close contact with the whites, and give them regular employment and regular income. Such parks would be admirable army posts for cavalry, which could be used to prevent trespass.

FORESTRY VERSUS LUMBERING.

By Dr. C. A. Schenck.

Suppose fate's kindness should make you the owner of 200,000 acres of virgin pine forests, containing 1,200 million feet of lumber, somewhere in Arkansas or Georgia. If you are a lumberman, you will erect a plant of about 100 million feet annual output, you will convert the entire stumpage within twelve years into gold standard money, and you will then look out for another field to employ both your money and your grit. The land, the little duchy of 200,000 acres you used to own—well, you throw it away; denuded of timber of it is not worth the taxes.

If you are a forester, you will start in a similar way; you will erect, perhaps, a plant of somewhat smaller capacity, say of 80 million feet per annum; a good mill you must have, for you want to cut all of the old timber which has stopped growing, which is approaching its natural limit of life, and convert it into money as rapidly as possible. One thousand million feet of the 1,200 million you are likely to find consisting of mature and hypermature trees. In 12½ years your mill will have consumed them. The 200 million originally left on the ground consist of thrifty trees growing at an annual rate of about 5 per cent. In 12½ years, at that rate, they have developed into 360 million. In addition, the young trees originally overlooked have grown into size worth tallying; at the end of the 12½ years' campaign you are likely to find 200 million of them. Of course the forest then contains smaller and less timber than there was found at the start. But all of it is thrifty and surrounded by an abundant progeny of sapling-size, ready to shoot ahead as soon as the "parents" have been removed.

From now on the forester curtails his annual cut. The forest does not contain hypermature trees. Only that number of feet is annually cut, selected from the largest and best trees left, which will equla the annual productiveness of the ground, say 40 million feet. A large production we cannot expect on pine soil. Were the soil better, producing annually 300 or 400 feet per acre, then agriculture should occupy it, which on rich soil, without a doubt, is the most remunerative business.

Poor soil, rough climate, steep mountains, are the domain of forestry. Under reversed conditions, agriculture ought to monopolize the use of the ground, and, be it after lumbering or after forestry, the ground should be made ready for the plough as rapidly as possible.

But we must return to our example: As long as the forester, after withdrawing from the forests in 12½ years the extraordinary surplus of primeval trees, restricts the annual harvest to the amount of the annual production, the forest will act like the hen laying golden eggs. Forty million feet is, we have assumed, our annual production.

The trees grow, as sure as the sun shines and as sure as the rain falls—sunshine, air, and water being the main factors of wood fibre. In years of low prices the forester will restrict or stop cutting; in years of good prices he will double or treble the output—always, however, keeping close to the average of 40 million per year.

The lumberman is an economic nomad, shifting his business from one tract to the other, and taking one risk after the other.

The forester is an economic settler, sticking to the original place of investment and continuing on it a business which he has once found remunerative.

He does not, of course, stick to the original total amount invested; he begins with 6,000 feet per acre, he continues with, say, 1,800 feet per acre. He keeps on the

ground that value of stumpage which yields him the highest interest in the safest manner.

The lumberman cuts every merchantable tree, not stopping to think whether it grows at an annual rate of 2 per cent. or 10 per cent.

The forester cuts only such trees, but all such trees, the rate of growth of which has fallen below the percentage desired by him.

LOGGING EXPENSES.

It is obvious that the logging expenses in forestry, to begin with, are higher than in lumbering. The expenses for trams, roads, trails, and dams are the same, whether 6,000 feet of lumber or only 5,000 feet of lumber are cut per acre. If the system of transportation costs, on an average, 60 cents per acre, then in the case of forestry 5,000 feet, and in the case of lumbering 6,000 feet, will share, in the expense making it for the one 12 cents and for the other 10 cents per 1,000 feet.

There are other factors resulting in higher logging expenses under forestry methods. Care must be taken to prevent the remaining growth from being injured when the majority of the timber is cut and removed. The difficulty of supervising contractors and workmen is increased. For railroad ties, road poles, corduroy timber, etc., not the best and handiest saplings must be used. Trees or poles of inferior quality must suffice the task.

There cannot be any doubt that the logging expenses per 1,000 feet, board measure, during the first "campaign," are higher in forestry than in lumbering. During the second campaign, however, they will be lower than usual, owing to the fact that the system of transportation needs only reviving in order to be available for another run.

Suppose the logs cost us, per acre, 30 cents extra under forestry during the first campaign. What does that mean? It means that we have invested, per acre, 30 cents in second growth forest. Our extra expense of 30 cents has resulted in its production. Towering over the second growth, consisting of seedlings and saplings, we find those trees of merchantable qualities which we saved out of the 6,000 feet per acre at the first campaign, because they were then growing at a high rate of interest. The free position of their crowns has of late given their growth an additional impetus. Now, in the course of the next campaign they will be cut, partly on account of their gradually slackened growth, partly on account of the demands for light from the side of the undergrowth at their feet.

THE NEW FOREST AND ITS VALUE.

These mother trees have yielded us, by their annual growth, about 5 per cent. interest on their value. They have further completed the seeding of the ground and have created an embryo forest, free of charge—aside from the expense of 30 cents mentioned above.

If this embryo forest and the saplings, poles, and young trees mixed with it are worth over 30 cents per acre, then forestry was, in the given example, a more remunerative business than lumbering.

Virginity of the forest" has gone for good. The new forest will last forever; the largest trees will be periodically cut in every section, and a period of a few years will be enough to replace them by those next in size.

Now, what is such a forest worth, containing all sizes of trees, all healthy and vigorous, none over-aged and decrepit? The problem is easy to solve. A farm which

rents out at 50 cents per acre, and on which 10 cents taxes are annually due, is worth $\frac{50-10}{0.05}=800$ cents per acre.

A forest which yields, on the average, annually 200 feet, board measure, per acre, worth 30 cents—these 200 feet are obtained by shaving off always the oldest and largest trees—and on which 5 cents taxes are annually due, is worth $\frac{30-5}{0.05}=500$ cents per acre.

In other words, at an extra expense of 30 cents in our logging operations, and by leaving 1,000 feet, board measure, of thrifty timber on the ground in the first campaign, we have formed a forest worth $5.00 per acre, and on these $5.00 we shall annually make 25 cents revenue. Such must be the outcome as sure as the sun will shine and as sure as the rain will fall, for sunshine and rainfall—to repeat it—are the components of timber production. Men need not move a finger. Nature does not require any help.

FOREST FIRES.

Nature requires something else, and requires it badly: Protection from destruction by fires. In most sections of the United States the forestry problem is identical with the forest fire problem. As long as a second growth is exposed to fires of annihilating fierceness, there is no use of talking about forestry, there is no sense of leaving a stick of merchantable timber on the ground during the lumbering campaign. As the State does not protect our young forests from fire, we have to do it ourselves. The expense for protection will considerably curtail our future returns and the value of our forest. Supposing that protection costs us 10 cents per acre per annum, our forest is worth only $\frac{30-5-10}{0.05}=300$ cents per acre.

Even less than that; 5 per cent. interest on a somewhat risky investment does not seem sufficient. We shall have to capitalize our annual net yield with about 8 per cent., to bear due regard to the dangers threatening the undertaking. At 8 per cent., the value of our second forest will be $\frac{30-5-10}{0.08}=118$ cents per acre.

There are, to be sure, many tracts in the South where practical forestry is an absurdity, because fire cannot be controlled, owing to local and climatic reasons, or owing to the habits of the native population, unrestricted by education or law.

CONCLUSION.

On non-agricultural lands, forestry will pay better than lumbering.

(1) If the excess of logging expenses is outweighed by the value of the "new forest";

(2) If the taxes on the forest land are reasonable;

(3) If fires can be controlled.

Every wood owner, before beginning to cut the trees, should ask for an expert's advice whether lumbering or forestry will pay him best. Dollars and cents express the superiority of one method over the other, and a thorough knowledge of both methods combined with a little insight in banking and finances must be the umpire between forestry and lumbering.

FOREST-FIRE LAWS.

It seems to be the general experience of all countries that special laws enacted must be enforced by special authority to prevent forest fires. All the more pro-

gressive States have such laws, and the best of them are much like the forest fire law of Minnesota, of which the following is a digest. This act, which was passed by the Legislature of Minnesota in 1895, makes a systematic division of the State in such a way that every section of it is in charge of a forest fire warden. It provides for the appointment of a chief fire warden, who shall have supervision of all fire wardens. Supervisors of towns, mayors of cities, and presidents of village councils are constituted fire wardens in their respective towns, cities and villages. The chief fire warden has power to appoint as fire wardens other persons, as he may deem necessary, to protect unorganized territory. One-third of the expense is borne by the State and two-thirds by the counties. Under this act penalties are prescribed as follows:

The following are liable to a penalty not exceeding $100, or imprisonment not exceeding three years:

Any person refusing, without sufficient cause, to assist fire wardens in extinguishing forest or prairie fires.

Any fire warden who neglects to perform his duties.

Any person who wilfully, negligently, or carelessly sets on fire, or causes to be set on fire, any woods, prairies, or other combustible material, thereby causing injury to another.

Any person who shall kindle a fire on or dangerously near to forest or prairie land, and leave it unquenched, or who shall be a party thereto.

Any person who shall use other than incombustible fire wads for firearms, or carry a naked torch, firebrand, or other exposed light, in or dangerously near to forest land.

Any person who shall wilfully or heedlessly deface destroy, or remove any warning placard posted under the requirements of this act.

Any railroad company wilfully neglecting to provide

efficient spark-arresters on its engines, or to keep its right of way to the width of 100 feet cleared of combustible material, or which shall fail to comply with other provisions of section 12 of the above-mentioned act.

The following are liable to a penalty of not less than $5 nor more than $50:

Any railroad employé who wilfully violates the provisions of section 12 of this act, in regard to depositing live coals or hot ashes near woodland, and to reporting fires.

Any owner of threshing or other portable steam-engine who neglects to have efficient spark-arresters, or who shall deposit live coals or hot ashes without extinguishing the same.

The following are liable to a penalty not exceeding $500, or imprisonment in the State prison not over ten years, or both:

Any person who maliciously sets or causes to be set on fire any woods, prairie, or other combustible material whereby the property of another is destroyed and life sacrificed.

The effect of this law has been very beneficial, and has prevented much loss of property by fire; but the area to be covered is very large, much of it is very sparsely populated, and the funds available are very meagre for best results, so that, although it has been very ably enforced, and some convictions made under it, yet it should be amended in several respects to make it effective.

CHAPTER XV.

TABULAR CLASSIFICATION, SYLVICULTURAL DATA, AND USES OF THE IMPORTANT AMERICAN TIMBER TREES.

TABULAR CLASSIFICATION, SYLVICULTURAL DATA, AND USES OF THE IMPORTANT AMERICAN TIMBER TREES.

The Pines (*Pinus*).

The Pines are distinguished by their needles. which are in sheaves of two, three, or five, and by their cones, which require two seasons to mature.

Pine seeds should be kept dry and cool when stored. A dry loft or shed floor is a good place for them. In small quantities they are most safely stored over winter by stratifying them with dry sand and storing in a cold room. It is generally best to sow the seed in the spring, but with some kinds autumn sowing gives excellent results.

Name and Size.	Distribution.	Quality and Uses of Wood.	Remarks.
White Pine (Weymouth Pine) *Pinus strobus L.* Height, 150 ft. Diameter, 4 ft.	Minnesota and Iowa to the New England States and along the Alleghanies to Georgia, Manitoba to Newfoundland.	Light, soft, not strong nor durable in contact with the soil, free from resin and easily worked. Extensively used for lumber of different kinds, cabinet-work, timber, shingles, laths, and interior finish, cooperage, railroad ties, fuel, and for general construction purposes. Is the most useful of our American Pines.	Preferring somewhat clayey land and fresh deep soil; successful on range of soils from dry to moist; rapid grower, rather tolerant of shade, a magnificent ornamental tree; hardy, but little tolerant of drought; mixes with deciduous trees. One of the most important of our conifers. Slow of germination.
Red Pine (Norway Pine) *Pinus resinosa, Ait.* Height, 70 ft. + Diameter, 2 ft. +	Manitoba and Minnesota to Pennsylvania, New England, and Newfoundland.	Light, harder, and stronger than that of White Pine; elastic, resinous, coarser-grained. Used chiefly for lumber, for construction purposes, timber, and piles.	Adapted to many soils; best quality of timber produced in well-drained sands; extremely hardy; vigorous and rapid grower; intolerant.

Pitch Pine (Torch Pine) *Pinus rigida, Mill.* Height, 80 ft. Diameter, 1 to 3 ft.	New Brunswick to Georgia, Ontario, and Kentucky, and Tennessee.	Light, not strong, brittle, coarse-grained, very durable and very resinous. Used extensively in early times for sills and beams of buildings, and also in the manufacture of tar and turpentine.	Grows in dry, sandy, rocky, and barren soil. Growth rapid. Can be easily raised from seed on soil too sterile for other crops. It has been successfully cultivated in the New England States in this way; intolerant.
Jack Pine (Gray Pine) *Pinus divaricata (Ait.) Sudw.* Height, 40 to 60 ft. + Diameter, 2 to 4 ft.	New Brunswick, Maine, Northern New York, north to Hudson Bay, west to Minnesota and Northern Illinois, northwest to the Mackenzie River and the Rocky Mountains.	Soft, not strong and close-grained, resinous. Used for lumber, fencing, farm buildings, railroad ties, and fuel.	Adapted to dry, loose soil, a hardy tree which withstands drought well. Its growth is rapid, which has led it to be planted on the dry lands of the West to some extent. Intolerant; comes up on cut-over land.
Long-leaf Pine (Georgia Pine) *Pinus palustris, Mill.* Height, 100 ft. Diameter, 4 ft.	South Atlantic and Gulf States, Virginia to Texas; found only occasionally beyond 150 miles from the coast.	Heavy, very hard and strong, tough, close-grained, durable, very resinous. Used for masts and spars, building of bridges, viaducts, trestle work, railway cars and railway ties, fencing, flooring, interior finishings, fuel, and charcoal. Supplies the turpentine, pitch, and tar of commerce.	Does best on well-drained, loose, deep, sandy loam, or gravel with a clay sub-soil. Slow of growth and not shade-enduring. Develops a fairly strong tap-root. Most valuable Pine of the South. Is a poor seed; produces a fair seed year every five (5) years. Regeneration greatly hampered by the frequent ground fires occurring in the South.

TABULAR CLASSIFICATION, ETC., OF THE IMPORTANT AMERICAN TIMBER TREES—(*Continued*).

The Pines (*Pinus*).

Name and Size.	Distribution.	Quality and Uses of Wood.	Remarks.
Short-leaf Pine (Yellow Pine) *Pinus echinata Mill.* Height, 80 to 100 ft. Diameter, 4 ft.	New York to Florida, Missouri and Texas north to Kansas and Illinois.	Heavy, hard, strong, close-grained, resinous, easily worked. Used in the manufacture of sash, doors, and blinds, for cabinet making and for interior finish of buildings; flooring and shingles.	Borders of swamps and on light, sandy soil. Growth slow, rapid when young; will succeed on poor soil. Is often upturned on high exposed situations. Produces seed every year, and abundantly every three years.
Cuban Pine (Slash Pine) *Pinus heterophylla (Ell.) Sudw.* Height, 100 to 115 ft. Diameter, 2 to 3 ft.	Southern and Southeastern coast regions: South Carolina to Florida and Louisiana.	Very hard, strong, tough, durable, coarse-grained. Used for timber and spars, and in the manufacture of turpentine.	The most beautiful of the Southern Pines, becoming a factor in the restoration of the Southern Pineries. Produces a great number of seedlings every year which spring up and gradually crowd out the seedlings of other species. Intolerant.
Loblolly Pine (Old Field Pine) *Pinus tæda, L.* Height, 80 to 100 ft. Diameter, 2 ft.	Southeastern and Gulf States: New Jersey to Texas, and Arkansas to Tennessee.	Heavy, coarse-grained, fairly durable, strong, sapwood thick. Used chiefly for lumber and timber.	Inhabits lowlands, growing in small colonies. Of some importance as a lumber tree in the South. Best quality found west of the Mississippi. Intolerant. Occupies and grows very rapidly on abandoned fields.

Spruce Pine (Cedar Pine) *Pinus glabra, Walt.* Height, 100 ft.+ Diameter, 2 ft.+	South Carolina to Florida and Louisiana.	Light, soft, not strong, brittle, close-grained, not durable. Suitable for carpentry. Used mostly for fuel and the sawmill.	Grows principally on low terraces mixed with deciduous trees. One of the largest Pine trees of North America, but of little recognized economic value. Flourishes when young in the shade of its deciduous neighbors.
Scrub Pine (Jersey Pine) *Pinus virginiana, Mills.* Height, 40 ft. Diameter, 18 in.+	New York to South Carolina, Indiana and Alabama.	Light, soft, not strong, brittle, close-grained, durable in contact with the soil. Used for lumber, water pipes, pump logs, fuel.	Grows on light, sandy soil. In the East, it spreads rapidly over fields exhausted by agriculture, for which it is chiefly valued.
Bull Pine (Yellow Pine) *Pinus ponderosa, Laws.* Height, 150 to 200 ft. Diameter, 5 to 6 ft.	British Columbia to Nebraska, and Montana to Colorado, California to Northern Mexico, Idaho, and the Black Hills of South Dakota.	Heavy, hard, strong, close-grained, not durable in contact with the soil. Used for lumber, construction purposes, railway ties, fencing, fuel, mining timbers.	One of the most important forest trees of the Western United States and Canada. Grows usually on the slopes of the mountain ranges, and on dry, gravelly plains. Liable to fungous diseases. Intolerant. Resists fire very well.

TABULAR CLASSIFICATION, ETC., OF THE IMPORTANT AMERICAN TIMBER TREES—(*Continued*).

The Pincs (*Pinus*).

Name and Size.	Distribution.	Quality and Uses of Wood.	Remarks.
Rock Pine *Pinus ponderosa* var. *Scopulorum, Engelm.* Height, 150 to 200 ft. Diameter, 5 to 6 ft.	Rocky Mountains to Nebraska, and Montana to Colorado.	Harder, more brittle and resinous and coarse-grained than the wood of *P. ponderosa.* Used for the same purposes as the Bull Pine.	The principal lumber tree of the Rocky Mountains. Wonderfully hardy and doing well in severest situations in the prairie States. Of slow growth. Tolerant; windfast.
Jeffrey Pine (Black Pine) *Pinus jeffreyi, Murray.* Height, 100 ft.+ Diameter, 5 ft.+	California, eastern slope of Sierra Nevadas, and Oregon.	Hard, coarse-grained, very resinous. Color light yellow. Used for lumber and in construction; fuel. Sap has been used in the manufacture of certain medicinal preparations.	Quite common in mountains of California, where it is an important lumber tree. Occurs on the high exposed ridges.
Lodgepole Pine (Tamarack Pine) (Jack Pine) *Pinus murrayana* "Oreg. Com." Height, 80 to 150 ft. Diameter, 2 to 5 ft.	Alaska to California, Montana and New Mexico, Rocky Mountain regions.	Soft, tough, light-colored, close-grained, not durable. Used mostly for lumber, fuel, and ties.	Tall, slender trees, growing usually in fresh, sandy, and clayey loams on the mountain sides. Trees often subject to attacks of insects and bark-eating birds.

Monterey Pine *Pinus radiata*, *Don.* Height, 80 to 100 ft. Diameter, 2 to 5 ft.	South California coast.	Light, soft, not strong, brittle, close-grained. Formerly manufactured into lumber, now chiefly used for fuel.	Has been cultivated largely for its abundant foliage, great endurance, and rapid growth. Does well in exposed locations and barren soil.
Silver Pine (Western White Pine) *Pinus monticola*, *Dougl.* Height, 100 to 150 ft.+ Diameter, 4 or 5 ft.	British Columbia to California, Idaho and Western Montana.	Light, soft, not strong, close, and straight-grained. Sometimes used for lumber; a substitute for White Pine in the Western States.	A hardy tree, but grows slowly under cultivation.
Sugar Pine *Pinus lambertiana*, *Dougl.* Height, 200 ft.+ Diameter, 6 ft.+	Oregon to California, slopes of the Sierra Nevada Mountains.	Light, soft, straight-grained, fragrant, satiny, easily worked. Used in the manufacture of lumber for interior finish, doors, shingles, sash, woodenware, and in cooperage A sweet, sugar-like matter which exudes from its heart wood, when wounded, possesses powerful diuretic properties.	A tree of great size and beauty. "The crowned Prince of the Pine family," the dominant tree of the whole Western world. Bears long, graceful pointed cones. Grows slowly and does not assume its true habit under cultivation in the East.

TABULAR CLASSIFICATION, ETC., OF THE IMPORTANT AMERICAN TIMBER TREES—(*Continued*).

The Pines (*Pinus*).

Name and Size.	Distribution.	Quality and Uses of Wood.	Remarks.
Limber Pine (White Pine) *Pinus flexilis, James.* Height, 40 to 50 ft. Diameter, 2 to 4 ft.	Eastern slopes of Rocky Mountains; Alberta to Texas, and Utah, Nevada, Arizona, and California.	Light, soft, close-grained, color pale yellow, turning red on exposure to the air. Manufactured into lumber and used in construction and for domestic purposes.	Grows scattered, or it grows among other conifers. Grows slowly under cultivation, and not suitable for planting. Grows best in the mountains at high altitudes.
Foxtail Pine (Spruce Pine) *Pinus balfouriana, Murr.* Height, 30 to 40 ft. Diameter, 1 to 2 ft.	California.	Soft, weak, brittle, heavy, close-grained, satiny; takes a good polish. A tree of little economic importance except for fuel.	Sometimes forms extensive open groves mixed with other pines. Also occurs as a shrub. Hardy, but of slow growth. Does not grow to a very desirable size.
Bristle-cone Pine (Hickory Pine) *Pinus aristata, Engelm.* Height, 40 to 50 ft. Diameter, 2 to 3 ft.	Colorado to California.	Light, soft, close-grained, not strong, color red. Sometimes used for timbers of mines and for fuel.	Nowhere very abundant, frequently shrubby. Not desirable for planting, as it is a slow grower.

Larches.

Large, deciduous, cone-bearing trees. Leaves, needle-shaped, soft, deciduous, clustered except on young shoots, where they are spirally arranged. Propagated by seed as recommended for the pines. Seed ripe in autumn. Cones mature in one season. Seedlings should be planted in autumn or very early in spring, as buds start early.

Tamarack (American Larch) *Larix laricina Du Roi Koch.* Height, 100 ft + Diameter, 3 ft. +	Minnesota to Illinois, Newfoundland and Labrador; northeast to Great Bear Lake and Mackenzie River.	Very resinous, hard, strong, durable, very heavy. Used chiefly for ship-building, posts, ties, telegraph poles, rough lumber, fence rails and fuel.	Growth rapid, readily propagated by seed. Inhabits cold swamps, often to the exclusion of all other trees. Adapted to planting along lake shores and sloughs, but of little value for dry soils. Intolerant. Specific gravity, 0.6236 Weight of a cu. ft., 38.86 lbs.
Western Larch. *Larix occidentalis, Nutt.* Height, 200 ft.+ Diameter, 6 ft.+	Montana to Oregon and British Columbia.	Very heavy, hard, strong, and close-grained; durable in contact with the soil. Takes a good polish. Used for lumber, railway ties, fence posts, for interior finishings, and in cabinet making.	The noblest of the Larch trees, and one of the most valuable timber trees of the continent. Produces abundant seeds, grows rapidly, and has a peculiarly thick bark, which characters fit it to survive in the great struggle for existence. Specific gravity, 0.7407 Weight of a cu. ft., 46.16 lbs.

TABULAR CLASSIFICATION, ETC., OF THE IMPORTANT AMERICAN TIMBER TREES—(*Continued*).

Spruces (*Picea*).

Leaves, evergreen, scattered, jointed on a persistent base, needle-shaped, generally four-angled, short, pointing every way, and all of one kind. Cones mature the first year, hanging downward on the branches, not falling to pieces. Seed should be treated as recommended for the Pines.

Name and Size.	Distribution.	Quality and Uses of Wood.	Remarks.
Black Spruce *Picea mariana,* *(Mill.) B. S. P.* Height, 90 ft.+ Diameter, 2 to 3 ft.	Minnesota to North Carolina, Hudson Bay, Mackenzie River, and Rocky Mountains.	Light, soft, not strong. Used for paper pulp, lumber, flooring, masts, spars, shipbuilding, and various small articles where a stiff wood is needed.	Rather short-lived on dry soil, and a poor ornamental tree. Has been sought after as a Christmas tree. The gum which exudes from this tree is much valued as a chewing gum. Is the principal conifer in the far North.
Red Spruce *Picea rubens,* *(Poir.) Diet.* Height, 80 to 100 ft. Diameter, 2 to 4 ft.	Nova Scotia to North Carolina and Tennessee.	Light, soft, close-grained, slightly tinged with red, not strong, nor durable when exposed to the weather. Used for flooring, joists, scantlings, square timber for construction, sounding boards for instruments, and for paper pulp.	Inhabits well-drained hillsides. Its growth is slow, but, because of its dense branches and the dark coloring of its foliage, it is valuable as an ornamental tree in suitable climates. Roots shallow, often thrown by the wind. Very tolerant when young.

White Spruce *Picea canadensis (Mill.) B. S. P.* Height, 100 ft.+ Diameter, 3 ft.+	Minnesota to Maine, Labrador and Hudson Bay, and Black Hills to Montana, British Columbia, and Alaska.	Light, soft, not strong, straight-grained, with a satiny surface. Used for lumber, interior finish, paper pulp.	An excellent tree for the massiveness of its trunk and the beauty of its foliage. In favorable cold climatic conditions, it is a desirable tree for parks and gardens.
Engelmann Spruce *Picea engelmanni, Engelm.* Height, 150 ft.+ Diameter, 4 ft.+	Arizona to British Columbia, Rocky Mountain regions.	Light, soft, not strong, close- and straight-grained, with a satiny surface. Manufactured into lumber and is also used extensively for fuel and charcoal. Bark employed for tanning purposes.	This tree forms extensive forests in certain localities in the Rocky Mountain regions, and is valuable as an ornamental tree. Hardy and symmetrical in shape. Suited to a variety of soils. Is one of the most tolerant of Spruces.
Sitka Spruce *Picea sitchensis, Boug.* Height, 200 ft. Diameter, 15 ft.+	Pacific Coast, Alaska to California.	Light, soft, not strong, straight-grained, satiny. Used for lumber, interior finish, fencing, dunnage of vessels, woodenware, and packing cases, boat building and cooperage.	Confined to alluvial plains and moist-bottomed lands. Possessed of vigorous growth and vitality, and with its beautiful foliage it makes a fine forest tree.

TABULAR CLASSIFICATION, ETC., OF THE IMPORTANT AMERICAN TIMBER TREES—(*Continued*).

Hemlocks (*Tsuga*).

Leaves, short, needle-shaped, flat; cones small, scarcely longer than the leaves, hanging from the tips of the branches. Seed is treated for propagation purposes the same as the Pines. Cones mature the first year.

Name and Size.	Distribution.	Quality and Uses of Wood.	Remarks.
Hemlock (Hemlock Spruce) *Tsuga canadensis, (L.) Carr.* Height, 100 ft. Diameter, 2 to 4 ft.	Nova Scotia to Minnesota, south to Delaware, along the Alleghanies to Alabama.	Wood soft, weak, brittle, close-grained, light brown, difficult to work, not durable when exposed to the air, but lasts well in the soil. Used for coarse lumber, outside finish, railway ties. Canada pitch and opaque resin important products of the wood. Oil of hemlock distilled from young branches.	A very graceful tree, which under cultivation has given rise to a number of forms. A favorite ornament of parks and gardens. Liable to windshake and splinter. Bark used for tanning purposes. Tolerant. Reproduction good.
Western Hemlock (Hemlock) *Tsuga mertensiana (Boug.), Carr.* Height, 150 ft.+ Diameter, 6 ft.+	Alaska to California and Montana.	Light, hard, tough, pale brown tinged with yellow, durable and easily worked. Used for lumber and in the construction of buildings. Bark furnishes valuable tanning material.	The noblest of Hemlock trees. With its long, drooping branches, it makes a graceful tree. Requires moist soil and rather moist climate. It attains its greatest development in moist valleys and on low slopes near the coast. Is an abundant seed producer. Regeneration is good. Tolerant.

Pseudotsuga.

Resembles the Hemlocks, but the cone is covered with prickles and the trees are more upright in growth. Cones mature the first year.

Douglas Spruce (Red Fir) (Douglas Fir) *Pseudotsuga taxifolia, (Poir.) Br.* Height, 150 to 300 ft. Diameter, 3 to 10 ft.	British Columbia to California, Mexico, Montana to Texas.	Heavy, hard, close-grained, difficult to work, durable, very strong. Used for lumber, construction, fuel, railway ties. Bark used for tanning. Large timbers, ship-building.	A widely distributed tree, hardy and thrifty, and grows rapidly from seed. One of the most important elements of the American forest. Hardy over a wide range. In Rocky Mountains, grows on dry, rocky, exposed mountain ridges. Attains its largest size in the moist climate on the western slope of Cascade Mountains.

Firs (*Abies*).

Resemble the Spruce, but with the most striking differences in the form of the trees, which are very regularly conical. Needles flat, cones upright on the branches and falling to pieces at maturity. Cones mature the first year. Seeds managed as directed for the Pines.

Balsam Fir *Abies balsamea, (L.) Mill.* Height, 60 ft. Diameter, 1 to $1\frac{1}{2}$ ft.	Minnesota and Iowa to Newfoundland, Virginia, Labrador, Hudson Bay, and northwest to Great Bear Lake region and Rocky Mountains.	Light, soft, weak, coarse-grained, not durable in contact with the soil. Used for laths, shingles, boxes, packing, and pulp making. Bark used in manufacture of Canada balsam.	Grows in cool situations with abundant moisture. Hardy and fast-growing; not suitable for planting, as it does not seem to thrive when removed from its natural habitat, becoming prematurely old.

TABULAR CLASSIFICATION, ETC., OF THE IMPORTANT AMERICAN TIMBER TREES—(*Continued*).

Firs (*Abies*).

Name and Size.	Distribution.	Quality and Uses of Wood.	Remarks.
Lowland Fir (Great Silver Fir) *Abies grandis, Lindl.* Height, 250 ft.+ Diameter, 4 ft.	Montana to Vancouver Island and California.	Light, soft, coarse-grained, weak, not durable, light brown. Used for lumber, interior finish, packing cases, and cooperage.	Attains best size on alluvial bottom lands of streams. A very stately tree, but has been little cultivated.
White Fir. *Abies concolor, (Gord.) Parry.* Height, 200 ft.+ Diameter, 5 ft.+	Oregon to California, Colorado and New Mexico.	Light, soft, close-grained, weak, not durable. Color pale brown. Used for lumber, packing-cases, and butter-tubs.	Inhabits lowlands and high elevations, forming extensive forests. A hardy, handsome tree of vigorous growth, capable of withstanding attacks of diseases and insects. A promising ornamental tree for parks. Intolerant in Rocky Mountains and Colorado. Suitable to a wide range of soils.
Amabalis Fir (White Fir) *Abies amabalis, (Loud.) Forb.* Height, 200 ft.+ Diameter, 4 to 6 ft.	Oregon to British Columbia.	Light, hard, not strong, close-grained. Color pale brown. Used for lumber, interior finish of buildings, fuel.	Inhabits slopes of mountain ranges and in meadows singly or in groves. A very beautiful tree, with snowy bark and dark-green foliage. Growth slow, not promising under cultivation.

Noble Fir (Red Fir) *Abies nobilis, Lindl.* Height, 150 ft.+ Diameter, 6 ft.+	Washington to California.	Light, hard, strong, close-grained, pale brown. Used for lumber, interior finish, packing-cases.	One of the stateliest and finest inhabitants of the Western forests. A hardy tree, which grows well under cultivation.
Red Fir *Abies magnifica, Murr.* Height, 200 ft.+ Diameter, 8 ft.+	California, Mount Shasta, and western slope of Sierra Nevadas.	Light, soft, not strong, quite durable in contact with the soil. Color light brown or red brown. Used for lumber, fuel, packing-cases, and in construction.	Abundant in its range. Hardy in sheltered positions, and does fairly well under cultivation.

Cypress.

Deciduous trees, with tall trunks, furrowed, scaly bark, and erect, ultimately spreading branches. Cones produced in pairs, irregularly scattered, globose, maturing the first year. Leaves linear-lanceolate, appressed.

Bald Cypress *Taxodium distichum, (L.) Rich.* Height, 150 ft. Diameter, 4 ft.+	Delaware to Florida, Texas and Missouri.	Light, soft, close and straight-grained, weak, easily worked, light or dark brown, very durable. Used for railway ties, posts, fences, in construction and cooperage, and in manufacture of sash, doors, balustrades, rafters of glass-houses, and shingles. Very durable.	Inhabits river swamps and low banks, usually submerged during several months of the year. A form of this tree has been cultivated in gardens as an ornamental tree and is quite hardy. "Block Cypress" and White Cypress are forms of this tree.

TABULAR CLASSIFICATION, ETC., OF THE IMPORTANT AMERICAN TIMBER TREES—(*Continued*).

Sequoias.

Resinous, aromatic trees, with massive trunks and thick bark of two layers. Leaves linear-acute. Cones oblong, three-quarters of an inch to an inch long and half an inch broad. Seeds small with wings as broad as the body. Cones mature the first season.

Name and Size.	Distribution.	Quality and Uses of Wood.	Remarks.
Big Tree (Giant Sequoia) *Sequoia washingtoniana, Winsl.* Height, 275 ft.+ Diameter, 20 ft.+	California, western slope of Sierra Nevadas. Limited to small groves in this region.	Light, soft, not strong, brittle, coarse-grained, durable in contact with the soil. Color bright red. Used for lumber, fencing, shingles, in construction and finishing.	The largest inhabitant of the American forest. Does not flourish under cultivation, but is a fairly rapid grower.
Redwood. *Sequoia sempervirens (Lamb.) Endl.* Height, 200–300 ft. Diameter, 20 ft.+	California coast region. A narrow strip along the Pacific coast from Oregon to Monterey County, California.	Light, soft, brittle, weak, close-grained, easily worked, and very durable in contact with the soil; takes a good polish. Used for lumber, building material, shingles, fence-posts, telegraph-poles, railway ties, wine butts, tanning and water tanks, coffins and veneering.	Exceeded in size only by *Sequoia washingtoniana*, and is the most valuable timber tree of the western American forests. A hardy and stately tree, cultivated mostly as a curious tree.

Cedars.

Resinous trees with slender, erect branches and four-ranked, scale-like leaves. Easily raised from seeds. Seeds nearly surrounded by their wings. Cones mature in one season.

Arborvitæ (White Cedar) *Thuja occidentalis (L.).* Height, 50 to 60 ft. Diameter, 2 to 3 ft.	Minnesota to Lake Winnipeg, James Bay, Illinois, North Carolina, New Brunswick, and Nova Scotia.	Light, soft, brittle, coarse-grained, very durable in contact with the soil. Used for fence-posts and rails, railway ties, shingles. Young branchlets of medicinal value.	A common and widely distributed tree. Inhabits swamp lands, forming dense forests. Cultivated mostly for hedges, but requires protection from weather.
Giant Arborvitæ (White Cedar) *Thuja plicata, Don.* Height, 200 ft. Diameter, 15 ft.	Alaska to California and Montana.	Light, soft, not strong, brittle, coarse-grained, easily worked, durable in contact with the soil, dull brown tinged with red. Used for sash, doors, fences, shingles, interior finish, and in cabinet-making and cooperage.	One of the most important forest trees of northwestern America. Prefers moist or fresh, loamy soil, but often found on dry mountain sides at rather high elevations. Hardy and occasionally cultivated.
Incense Cedar (White Cedar) *Libocedrus decurrens, Torr.* Height, 150 ft. Diameter, 8 ft.	Oregon to Lower California and Nevada.	Light, soft, close-grained, not strong, durable in contact with the soil. Used for laths, shingles, fencing, furniture, interior finish, and in construction of flumes. Bark contains tannin.	Usually found in isolated groves. A very valuable timber tree. Suitable for moist soils. Prefers rather dry situations. A rapid grower, often cultivated in gardens, but liable to injury by rot.

TABULAR CLASSIFICATION, ETC., OF THE IMPORTANT AMERICAN TIMBER TREES—(*Continued*).

Cedars.

Name and Size.	Distribution.	Quality and Uses of Wood.	Remarks.
White Cedar *Chamæcyparis thyoides*, (*L.*) *B. S. P.* Height, 70 to 80 ft. Diameter, 3 to 4 ft.	Coast region, Maine to Florida and Mississippi.	Light, soft, weak, close-grained, easily worked, very durable in contact with the soil. Does not warp or check. Used for telegraph-poles, fence-posts, railway ties, woodenware, shingles, interior finish of houses, and in boat-building and cooperage.	Inhabits cold immersed swamps. An easy grower, highly prized as an ornamental tree.
Port Oxford Cedar (Lawson's Cypress) *Chamæcyparis lawsoniana*, (*Murr.*) *Parl.* Height, 200 ft. Diameter, 12 ft.	Coast region, Oregon to California.	Light, hard, strong, very close-grained, resinous, durable in contact with the soil. Used for lumber, interior finish, flooring, railway ties, fenceposts, in ship-building, and in manufacture of matches. Its resin is a powerful diuretic.	The most valuable tree in its class, and one of the most important timber trees of North America. Young trees make very beautiful ornamental trees for gardens. Comes up and thrives on dry, sandy ridges, but reaches its best development in the moist climate of the Redwood district.

Junipers (*Juniperus*).

Seed in fleshy berry-like coverings. Should be stratified in sand outdoors during winter, and even then will not start until after a year. Fruit matures the first, second, or, rarely, the third season.

Red Juniper (Red Cedar) (*Juniperus virginiana L.* Height, 100 ft. Diameter, 4 ft.	North Dakota to New Brunswick, Florida, Texas, Nebraska, and Indian Territory.	Light, soft, close-grained, brittle, not strong, durable in contact with the soil. Used for posts, railway ties, sills of buildings, interior finish, tubs, pails, lead-pencils, and in cabinet-making. Fruit and leaves used for medicinal purposes.	Inhabits swamps, alluvial plains, and river bluffs. Attains large size only in the South. A very hardy tree, valuable as an ornamental tree, but slow of growth. Excellent for windbreaks and hedges.
Western Juniper *Juniperus occidentalis, Hook.* Height, 60 ft. Diameter, 3 ft.	Western Idaho, Eastern Washington and Oregon, slopes of Cascade and Sierra Nevada Mountains, south to San Bernardino Mountains, California.	Light, soft, very close-grained, durable in contact with the soil. Used for fencing and fuel. Fruit gathered and eaten by the Indians of California.	Inhabits mountain slopes, high prairies, and meadows in rich moraine soil. A hardy tree with massive stem and far-spreading branches. A good tree for windbreaks.

Yew.

Treat seed as recommended for Juniper. Seed matures the first season.

Pacific Yew *Taxus brevifolia, Nutt.* Height, 50 to 70 ft. Diameter, 2 to 4 ft.	California to British Columbia and Montana.	Heavy, hard, strong, brittle, close-grained, very durable in contact with the soil, takes a beautiful polish. Used for fence-posts and fuel and by the Indians of the Northwest for paddles, spear handles, bows, fish-hooks, etc.	Inhabits shady banks of mountain streams, deep gorges, and damp ravines. A tree of but little commercial value.

TABULAR CLASSIFICATION, ETC., OF THE IMPORTANT AMERICAN TIMBER TREES—(*Continued*).

Deciduous-leaved Trees: Walnut Family.

Leaves compound, fruit a nut that should be planted in autumn or stratified in winter and sown in spring. Fruit matures the first year.

Name and Size.	Distribution.	Quality and Uses of Wood.	Remarks.
Butternut (White Walnut) *Juglans cinerea L.* Height, 100 ft. Diameter, 2 to 3 ft.	Minnesota and South Dakota to New Brunswick, Georgia, and Arkansas.	Light, soft, not strong, rather coarse-grained, takes a beautiful polish. Color light brown with thin, light-colored sapwood. Used for interior finish, cabinet-making, furniture, and tool handles.	In rich, deep, moist, not wet, soil, banks of streams, low, rocky hills. Does well in protected locations. Valuable as a shade tree and for timber plantings. Somewhat hardier than Black Walnut.
Black Walnut *Juglans nigra L.* Height, 100 ft. Diameter, 4 to 6 ft.	Minnesota to Ontario, and Massachusetts, Florida, and Texas.	Heavy, hard, strong, coarse-grained, easily worked, durable in contact with the soil. Takes a beautiful polish. Used in cabinet-making, for interior finish, flooring, gun-stalks, furniture, saw-handles, veneering, school apparatus, artists' goods, billiard-tables, carpet-sweepers, clocks, canes, and many smaller articles.	Inhabits rich bottom lands and fertile hillsides. Does well in protected locations on alluvial soil. Can be used to advantage in timber plantings, but liable to sunscald when exposed.

Pecan *Hicoria pecan* *(Marsh) Br.* Height, 170 ft. Diameter, 6 ft.	Iowa to Indiana, Alabama and Mexico.	Heavy, hard, weak, brittle, close-grained. Used in manufacture of wagons and agricultural implements, and for fuel.	In rich soil along streams. The largest of the Hickories. A large, graceful tree with beautiful green foliage. Desirable as an ornamental tree.
Bitternut *Hicoria minima* *(Marsh) Br.* Height, 100 ft. Diameter, 3 ft.	Minnesota to Maine, Florida and Texas.	Heavy, hard, strong, tough, close-grained, liable to check badly in drying. Used for ornamental purposes and hoop-poles. and other purposes similar to the Shagbark Hickory.	Borders of streams and swamps. high rolling uplands. A rapid grower, and one of the most beautiful of our forest trees.
Shagbark Hickory *Hicoria ovata* *(Mills) Br.* Height, 90 to 120 ft. Diameter, 3 to 4 ft.	Minnesota to Maine, Florida and Texas.	Heavy, very hard, strong, tough, close-grained, flexible, not durable when exposed to moisture. Used for axe and tool handles, 'phone blocks, wood screws, mallets, skewers, baskets, fuel, and in manufacture of farm implements, carriages, wagons, gymnasium apparatus.	In rich, moist soils, borders of swamps and streams and on low hills. A very slow grower, not very hardy; should be planted in favorable locations. A desirable tree for parks. Nuts valuable commercially.

TABULAR CLASSIFICATION, ETC., OF THE IMPORTANT AMERICAN TIMBER TREES—(*Continued*).

Deciduous-leaved Trees: Walnut Family.

Name and Size.	Distribution.	Quality and Uses of Wood.	Remarks.
Shellbark Hickory *Hicoria laciniosa* (*Mich.*) *Sarg.* Height, 120 ft. Diameter, 3 ft.	Iowa to New York, Pennsylvania and Indian Territory.	Heavy, very hard, strong, tough, very flexible. Used for handles of axes, tools, and in manufacture of wagons and farm implements.	Inhabits deep, rich bottom lands. A rapid grower, but not widely used for planting. Nuts used commercially.
Mocker Nut Hickory *Hicoria alba,* (*L.*) *Br.* Height, 100 ft. Diameter, 3 ft.	Ontario to Florida, Missouri and Texas.	Heavy, hard, strong, tough, close-grained, flexible. Used in manufacture of wagons and farm implements, for tool handles, etc.	In rich soil on ridges and hillside[illegible]. Grows to a large size a[illegible]d can be used to advan[illegible]ge in timber planting.
Pignut Hickory *Hicoria glabra* (*Mills*) *Br.* Height, 80 to 120 ft. Diameter, 3 to 4 ft.	Maine to Florida, Nebraska and Texas.	Heavy, hard, v[illegible]ong, tough, flexibl[illegible] and close-grained. Used in manufacture of wagons and farm implements and for tool handles.	In rich soil or on deep ridges and hillsides. Less variable than the other Hickories. Valuable for timber planting.

Willow Family.

Seeds ripen in summer. Difficult to grow from seeds under ordinary conditions, but most kinds seed freely and the seedlings spring up on the sand-bars and lake shores. Many kinds grow readily from cuttings; sprout readily from the trunk. Intolerant.

Aspen (American Aspen) (Poplar) *Populus tremuloides, Michx.* Height, 100 ft. Diameter, 2 to 3 ft.	Alaska to Labrador, Pennsylvania, Missouri, and Mexico.	Light, soft, strong, close-grained, of cottony fibre; soon decays in contact with the soil. Used for paper pulp, interior finish, turnery, and fuel. Young trees used for fence-posts and fence-rails.	Will grow in almost any kind of soil, but does best on moist ground. A rapid grower when young, but very slow when old. Common in cut-over timber land, where it is generally the first to take possession.
Large-tooth Aspen *Populus grandidentata, Michx.* Height, 60 to 70 ft. Diameter, 2 ft.	North Dakota to Nova Scotia, North Carolina and Tennessee.	Light, soft, close-grained, weak. Used in manufacture of wood pulp, in turnery, woodenware, for poles and various farm purposes.	In rich, sandy soil, borders on swamps and streams. A common inhabitant of forests. Has given rise to several varieties.
Balm of Gilead *Populus balsmifera* var. *Candicans (Ait.) Gray.* Height, 100 ft. Diameter, 6 ft.	Alaska to Newfoundland, New York, Minnesota, Nevada.	Light, soft, not strong, close-grained. Color light brown, with thick, nearly white, sapwood. Used in manufacture of paper pulp, pails, tobacco boxes, and small packing-cases.	Inhabits bottoms, swamp borders, and river banks. A rapid grower; frequently cultivated as a shade tree; sought for its fragrant buds, which are used for medicinal purposes.

TABULAR CLASSIFICATION, ETC., OF THE IMPORTANT AMERICAN TIMBER TREES—(*Continued*).

Willow Family.

Name and Size.	Distribution.	Quality and Uses of Wood.	Remarks.
Narrow-leaved Cottonwood *Populus angustifolia, James.* Height, 50 to 60 ft. Diameter, 1½ to 2 ft.	Assiniboia to Nevada, Arizona, New Mexico, and Nebraska.	Light, soft, weak. Used for various farm purposes, poles, fuel, fence-rails, building of log cabins in the West.	Inhabits banks of streams. A rapid grower, often planted as a shade tree in the West. Occasionally cultivated in gardens. Resists drought well.
Black Cottonwood *Populus trichocarpa, Torr and Gr.* Height, 175 ft.+ Diameter, 7 to 8 ft.	Alaska to California.	Light, soft, not strong, close-grained. Used in manufacture of woodenware, bowls, butter-tubs, and staves for sugar barrels.	One of the largest of the Poplars. Along streams, forming open groves. Makes a stately timber tree.
Fremont Cottonwood *Populus fremontii, Watts.* Height, 100 ft. Diameter, 5 to 6 ft.	California to Colorado, Texas and Mexico.	Light, soft, close-grained, weak, liable to warp in drying, difficult to season. Used mostly for fuel. Bark made into petticoats by Southwest Indians.	Along streams. Has been used extensively for planting streets and squares. A handsome tree, with cheerful foliage.
Cottonwood (Necklace Poplar) *Populus deltoides, Marsh.* Height, 100 to 150 ft. Diameter, 2 to 7 ft.	Quebec to Northwest Territory, south to New Jersey, Florida, Colorado, and New Mexico.	Light, soft, not strong, close-grained. Used for fuel, lumber, paper pulp, trays, bowls, and cheap packing-cases.	Inhabits moist soil, borders of swamps and streams. Planted extensively as a shade tree, windbreaks, and timber planting.

Birch Family.

Seeds ripen in autumn. May be successfully treated as recommended for Pine Seed.

White Birch (Gray Birch) *Betula populifolia, Marsh.* Height, 40 ft. Diameter, 18 ins.	Nova Scotia to Delaware and Lake Ontario.	Light, soft, not strong, close-grained, liable to check badly in drying, not durable in contact with the soil. Used in manufacture of spools, shoe-pegs, wood pulp, hoops for barrels, and for fuel.	Inhabits dry, gravelly soil, river bluffs, and borders of swamps and pools. Generally occurring on abandoned farm lands and burnt-over timber lands. Its rapid growth, beautiful foliage, and drooping, flexible branches make it a desirable tree for parks, lawns, and gardens. Intolerant.
Paper Birch (Canoe Birch) *Betula papyrifera, Marsh.* Height, 60 to 70 ft. Diameter, 2 to 3 ft.	Alaska to Labrador, Pennsylvania and Washington.	Light, strong, hard, tough, very close-grained, not durable. Used in manufacture of spools, bobbins, clothes-pins, bread-boards, rolling-pins, wood screws, shoe-pegs, wood pulp, and for fuel. Bark used by Indians for covering their canoes and houses, and for making baskets, drinking-cups, etc.	Does well on any retentive, moist soil; very hardy. A graceful tree with gleaming white bark and luxuriant foliage. Desirable for wind-breaks, lawn-planting, and pleasure-grounds. Intolerant.
River Birch (Red Birch) *Betula nigra L.* Height, 80 to 90 ft. Diameter, 2 to 5 ft.	Minnesota to Massachusetts, Florida and Texas.	Light, hard, strong, close-grained. Color light brown. Used in manufacture of wooden shoes, ox-yokes, and in cabinet-making and turnery.	Does well in deep, retentive soil. A rapid grower, attaining large size without vicinity of water. An admirable tree for parks of cold and temperate countries, but has rarely been planted.

TABULAR CLASSIFICATION, ETC., OF THE IMPORTANT AMERICAN TIMBER TREES—(*Continued*).

Birch Family.

Name and Size.	Distribution.	Quality and Uses of Wood.	Remarks.
Yellow Birch *Betula lutea, Michx.* Height, 75 ft. Diameter, 3 to 4 ft.	Minnesota and Western Ontario to Newfoundland, North Carolina and Tennessee.	Heavy, very strong, hard, and close-grained, satiny surface; takes a good polish. Used in manufacture of fine furniture, hubs of wheels, clothes-pins, shoe-pegs, tool handles, tripods, pill- and match-boxes, keels for ships, and for fuel.	Inhabits moist uplands in rich soil among the Pines, Maples, and Elms of northern forest. Requires low temperature. A large, handsome, and valuable timber tree. Not desirable for timber-planting, as it suffers from drought. Intolerant.
Cherry Birch (Sweet Birch) (Black Birch) *Betula lenta L.* Height, 80 ft. Diameter, 2 to 5 ft.	Rainy River to Newfoundland, Tennessee and Florida.	Heavy, hard, very strong, close-grained, satiny surface; takes a beautiful polish. Used in manufacture of furniture, in ship- and boat-building, and for fuel. Birch-oil obtained from wood and beer from fermented sap.	On uplands in rich soil. A handsome and graceful tree, with fragrant branches and dark-green foliage.

Beeches, Hornbeams, and Chestnuts.

Name and Size.	Distribution.	Quality and Uses of Wood.	Remarks.
Blue Beech *Carpinus caroliniana, Walt.* Height, 40 ft. Diameter, 2 ft.	Minnesota to Quebec, Florida and Texas.	Heavy, very strong, hard, close-grained. Used for levers, handles of tools, wooden bowls, and other small articles.	Borders of swamps and streams in deep, rich, moist soil. Of graceful habit and dark-green foliage. Tolerant. A desirable ornament for parks and gardens.

Beech *Fagus atropunicea* (*Marsh.*) *Sudwath* Height 70 to 120 ft. Diameter, 3 to 4 ft.	Wisconsin to Nova Scotia, Florida and Texas.	Hard, strong, tough, very close-grained; not durable in contact with the ground; difficult to season; takes a beautiful polish. Used in manufacture of chairs, shoe-lasts, plane-stocks, tool handles, and fuel.	In rich soil of uplands and mountain slopes. A fine forest tree, easily raised from seed, and easily transplanted; suitable for parks and pleasure-grounds. Very tolerant.
Ironwood (Hop Hornbeam) (Hornbeam) *Ostrya virginiana* (*Mill.*) *Koch.* Height, 50 to 60 ft. Diameter, 1 ft. +	Cape Breton Island to Minnesota, Florida and Texas.	Heavy, hard, strong, tough, very close-grained, durable in contact with the soil. Used for fence-posts, tools, and implements, and in homœopathic practice. Bark rich in tannin.	From dry, gravelly slopes and ridges mixed with Oaks, Maples, and other large trees, to low, moist places along river banks. Tolerant. A rapid grower, able to withstand fungal and insect diseases and winds. An excellent tree for parks and exposed situations.
Golden-leaf Chinquapin *Castanopsis chrysophylla* (*Hook.*) *de C.* Height, 100 to 150 ft. Diameter, 5 to 10 ft.	Oregon to California.	Light, soft, weak, close-grained. Used in manufacture of ploughs and agricultural implements.	An inhabitant of highlands. A beautiful tree with light-green foliage. Occasionally planted in gardens.

TABULAR CLASSIFICATION, ETC., OF THE IMPORTANT AMERICAN TIMBER TREES—(*Continued*).

Hornbeams, Chestnuts, and Oaks.

Name and Size.	Distribution.	Quality and Uses of Wood.	Remarks.
Chinquapin *Castanea pumila* (*L.*) *Mill.* Height, 50 ft. Diameter, 2 to 3 ft.	Pennsylvania to Florida, Missouri and Texas.	Light, hard, strong, close-grained, durable in contact with the soil. Used for fence posts and rails, railway ties. Nuts used commercially.	Inhabits sandy ridges, hillsides, borders of swamps. A hardy, often shrubby tree.
Chestnut *Castanea dentata* (*Marsh.*) *Borkh.* Height, 100 ft. Diameter, 3 to 4 ft.	Maine to Delaware, Michigan and Mississippi.	Light, soft, weak, coarse-grained. Liable to warp in drying, easily split, durable in contact with the soil. Used in manufacture of cheap furniture, fence posts and rails, railway ties. Contains tannic acid. Nuts gathered and sold in large quantities.	One of the most beautiful of our forest trees. Prefers a rich, deep soil. A rapid grower and highly esteemed ornamental tree. Does well under cultivation.

Oaks (*Quercus*).

Trees or shrubs with deciduous leaves, or in some species persistent, divided into two groups according to time required for ripening the seed; one group, the White Oaks, requiring one year, and the other, the Black Oaks, requiring two years.

Name and Size.	Distribution.	Quality and Uses of Wood.	Remarks.
White Oak (Stave Oak) *Quercus alba L.* Height, 130 to 150 ft. Diameter, 6 to 8 ft.	Minnesota to Maine, Florida and Texas.	Hard, strong, close-grained, durable. Used for ship-building, furniture, interior finish, fence-posts, railway ties, agricultural implements, coarse lumber, fuel, and in cabinet-making.	Thrives in variety of soils; best in moist, sandy loam and in warm situations. A slow and persistent grower. Most valuable of American Oaks. Acorns mature in one season.

California White Oak (White Oak) *Quercus lobata, Née.* Height, 100 ft. Diameter, 4 ft.+	California.	Hard, brittle, close-grained, difficult to season. Of little importance except for fuel.	Inhabits valleys of Western California, never forming dense forests, but beautiful park-like groves. Does not flourish when removed from its native habitat. Acorns mature the first season.
Post Oak (Iron Oak) (Box Oak) *Quercus minor (Marsh.) Sarg.* Height, 90 ft. Diameter, 2 to 3 ft.	Massachusetts to Florida, Nebraska and Texas.	Heavy, hard, close-grained; durable in contact with the soil; liable to check badly in drying; difficult to season. Used in manufacture of carriages, in construction, and for cooperage, fence-posts, railway ties, and fuel.	On dry, sandy soil and plains. A beautiful tree with dark foliage and a desirable ornament for parks, lawns, etc. Acorns mature the first season.
Bur Oak (Mossy Cup Oak) *Quercus macrocarpa, Michx.* Height, 160 ft. Diameter, 3 to 8 ft.	Nova Scotia and Maine to Manitoba, Montana, Pennsylvania and Texas.	Heavy, hard, strong, close-grained, durable in contact with the soil. Used for ship-building, fence-posts, railway ties, farm implements, coarse lumber, fuel, and in construction and cabinet-making.	Does well in a variety of soils. Best in moist, sandy loam and in warm situations. Resists drought well; extremely hardy. A slow but persistent grower. Most valuable of American Oaks. Acorns mature the first season. One of the best trees for prairie-planting.

TABULAR CLASSIFICATION, ETC., OF THE IMPORTANT AMERICAN TIMBER TREES—(*Continued*).

Oaks (*Quercus*).

Name and Size.	Distribution.	Quality and Uses of Wood.	Remarks.
Chestnut Oak (Rock Chestnut Oak) (Rock Oak) *Quercus prinus L.* Height, 70 ft. Diameter, 3 ft.+	Mountains, Maine to Alabama.	Heavy, hard, strong, tough, close-grained; durable in contact with the soil; difficult to season. Used for fence-posts, railway ties, and fuel. Bark rich in tannin and very valuable for tanning leather.	On hillsides and rocky banks of streams. A strong, vigorous tree of great beauty and attractiveness. Acorns mature the first season.
Chinquapin Oak (Chestnut Oak) *Quercus acuminata Michx. Houba.* Height, 80 ft.+ Diameter, 3 ft.+	New York to Alabama, Nebraska and Texas.	Heavy, hard, strong, dense, close-grained; durable in contact with the soil; liable to check badly in drying. Used in manufacture of wheels, for fencing and railway ties, and for cooperage.	On dry hills and limestone ridges, and on deep, rich bottom lands. A beautiful tree which attains a fine development, and worthy of attention for cultivating purposes. Acorns mature the first season.
Swamp White Oak (Swamp Oak) *Quercus platanoides (Lam.) Sudw.* Height, 60 ft.+ Diameter, 2 to 5 ft.	Maine to Georgia, Minnesota and Arkansas.	Heavy, hard, strong, close-grained. Employed same as White Oak and Bur Oak. Commercially wood is not distinguished from these two Oaks.	In swamps and moist soil and borders of streams, Usually forming small groves. Acorns mature the first season.

Cow Oak (Basket Oak) *Quercus michauxii, Nutt.* Height, 100 ft. Diameter, 3 ft.+	Delaware to Florida, Texas and Missouri.	Heavy, hard, very strong and tough, close-grained; durable in contact with the soil; easily split. Used in manufacture of agricultural implements, wheels, and strong baskets, in construction and cooperage, for fencing and fuel.	Inhabits borders of streams, low swamps, submerged bottom lands. One of the most important timber trees of North America. Acorns mature the first season.
Live Oak *Quercus virginiana Mill.* Height, 50 ft. Diameter, 3 ft.+	Shores from Virginia to Florida, Texas, California, Mexico, Central America, and Cuba.	Very heavy, hard, tough, strong, close-grained, satiny surface; takes a good polish; difficult to work. Used chiefly in ship-building, and in building of houses. Acorns afford valuable food for hogs.	One of the most valuable of American Oaks. A rapid grower, easily transplanted, and a beautiful shade tree give it front rank among our ornamental trees. Acorns mature the first season.
Canyon Live Oak (Maul Oak) *Quercus chrysolepis, Liebm.* Height, 40 to 50 ft. Diameter, 3 to 5 ft.	Oregon to California.	Heavy, hard, tough, very strong, close-grained; difficult to work. Used in manufacture of farm implements and wagons.	Not gregarious, often shrubby. A beautiful and majestic tree in certain localities. Acorns mature the second season.
Red Oak (Jack Oak) *Quercus rubra L.* Height, 100 ft.+ Diameter, 4 ft.	Minnesota to Nova Scotia, Georgia and Kansas.	Hard, strong, coarse-grained, reddish brown. Used in manufacture of chairs, in construction, for lumber, and interior finish.	Sandy soils and on hillsides. A rapid grower and a vigorous sprouter from stump. Very hardy. Bark used in tanning. Acorns mature the second season.

TABULAR CLASSIFICATION, ETC., OF THE IMPORTANT AMERICAN TIMBER TREES—(*Continued.*

Oaks (*Quercus*).

Name and Size.	Distribution.	Quality and Uses of Wood.	Remarks.
Scarlet Oak. (Jack Oak) *Quercus coccinea Muenchh.* Height, 60 to 80 ft. Diameter, 2 to 3 ft.	Minnesota to Maine, Nebraska, Tennessee, and North Carolina.	Heavy, hard, strong, coarse-grained. Used in the manufacture of chairs, tables, and for interior finish.	In moist or dry soil, well-drained places, and on hill-sides. The beauty of its foliage, its rapid growth, and hardiness make it a desirable ornamental tree. Acorns mature the second season.
Yellow Oak (Black Oak) (Quercitron Oak) *Quercus velutina, (Lam.)* Height, 70 to 80 ft.+ Diameter, 2 to 3 ft.+	Minnesota to Maine, Florida and Texas.	Heavy, hard, strong, not tough, coarse-grained, liable to check in drying. Used in manufacture of agricultural implements and in construction. Inner bark rich in tannin.	Inhabits dry, gravelly uplands and ridges. Frequently dwarfed and shrubby. Acorns mature the second season.
Spanish Oak (Red Oak) *Quercus digitata (Marsh.) Sudw.* Height, 70 to 80 ft. Diameter, 2 to 3 ft.	New Jersey to Florida, Illinois and Texas.	Heavy, hard, strong, coarse-grained, durable in contact with the soil; liable to check badly in drying. Used chiefly in construction and for fuel. Bark rich in tannin.	Inhabits dry, gravelly uplands or rich bottom lands of streams. A desirable ornamental tree. Acorns mature the second season. Sprouts vigorously from the stump.

Pin Oak (Swamp Oak) *Quercus palustris Muenchh.* Height, 70 to 80 ft. Diameter, 2 to 3 ft.	Wisconsin to Massachusetts, Virginia, Kansas, Indian Territory, and Texas.	Heavy, hard, strong, coarse-grained; liable to check in drying. Used in construction and for shingles and clapboards.	Borders of swamps and river bottoms in rich, moist soil. A rapid grower, hardy, and easily transplanted. A fine ornamental tree. Acorns mature the second season.
Water Oak (Spotted Oak) *Quercus nigra (L.)* Height, 80 ft. Diameter, 2 to 3 ft.	Delaware to Florida, Missouri and Texas.	Heavy, hard, strong, coarse-grained. Of little value except for fuel. Sometimes used for posts.	Borders of swamps and streams, rich bottom lands. A rapid grower, and easily transplanted. Desirable tree for planting in streets, parks. and lawns. Acorns mature the second season.
Tanbark Oak (Chestnut Oak) *Quercus densiflora, Hook. and Arn.* Height, 70 to 80 ft. Diameter, 2 ft.+	Oregon to California.	Hard, strong, close-grained, brittle. Used in construction and for fuel. Bark very rich in tannin.	On mountain slopes. A beautiful, symmetrical tree with dark foliage. Acorns mature the second season.

Elms and Allied Trees.

Seed ripens in early summer and should be sown at once in case of most species. Slippery-Elm seed should be sown in the spring.

Cedar Elm. *Ulmus crassifolia, Nutt.* Height, 80 ft. Diameter, 2 to 3 ft.	Mississippi to Arkansas and Mexico.	Heavy, hard, weak, brittle, close-grained. Used in manufacturing hubs of wheels, saddletrees, furniture, and fencing, lumber, and fuel.	In river valleys, on cliffs, and low hillsides in rich alluvial soil. An important Southern hardwood tree; sometimes planted as a shade tree.

TABULAR CLASSIFICATION, ETC., OF THE IMPORTANT AMERICAN TIMBER TREES—(*Continued*).

Elms and Allied Trees.

Name and Size.	Distribution.	Quality and Uses of Wood.	Remarks.
White Elm (American Elm) *Ulmus americana, L.* Height, 80 to 100 ft. Diameter, 3 to 6 ft.	Newfoundland to Rocky Mountains, Florida and Texas.	Heavy, hard, strong, tough, coarse-grained, difficult to split, durable. Used in manufacture of agricultural implements, hubs of wagon-wheels, saddle-trees, flour- and meal-barrels, cheese boxes, in cooperage and for flooring.	Along streams in moist soils to rather dry but rich soil. A rapid, often straggling, grower. Hardy tree for prairie-planting, one of best for streets and parks. Needs attentive pruning when young. Rather intolerant.
Cork Elm (Rock Elm) *Ulmus racemosa, Thomas.* Height, 80 to 100 ft. Diameter, 2 to 3 ft.	Minnesota to Quebec, New Hampshire, Missouri, Tennessee, and Nebraska.	Heavy, hard, very strong, and tough, close-grained, difficult to split, durable, flexible. Used in manufacture of agricultural implements, hubs of wagon-wheels, axe-handles, rims for bicycle-wheels, and for bridge timber, railway ties, sills of buildings.	On dry, gravelly uplands, low clay soil, rocky slopes, and river cliffs. A slow, sturdy, hardy grower, desirable for park- and street-planting.
Wing Elm (Wahoo) *Ulmus alata, Michx.* Height. 40 to 50 ft. Diameter. 1 to 2 ft.	Virginia to Florida, Missouri and Texas.	Heavy, hard, not strong, close-grained, difficult to split. Used for hubs of small trees and tool handles.	On dry, gravelly uplands, borders of swamps and streams, in rich alluvial soil. A rapid grower and a desirable ornamental tree.

Slippery Elm (Red Elm) *Ulmus pubescens, Walt.* Height, 40 to 60 ft. Diameter, 1 to 2 ft.	North Dakota to Quebec, Florida and Texas.	Heavy, hard, strong, durable in contact with the soil, easy to spilt when young. Used in manufacture of sleigh-runners, running-gear of carriages, hubs of wheels, ribs of canoes and skiffs, sills of buildings, agricultural implements, and for railway ties. Inner bark mucilaginous and nutritious.	Banks of streams and low, rocky hillsides in deep, rich soil. A handsome, shapely, fast-growing tree under cultivation.
Hackberry (Sugarberry) *Celtis occidentalis L.* Height, 100 ft. Diamete 2 to 3 ft.	Quebec to Massachusetts, Florida, Texas, Washington, Nevada, and Dakota.	Heavy, rather soft, not strong, coarse-grained. Used in harness-making, for fencing and cheap furniture.	On dry, gravelly hillsides in deep, rich soil. Withstands drought very well. Grows on the prairies. Desirable as a shade tree for parks and lawns and for prairie-planting. Seed should be stratified and sown in autumn. Ripens in autumn.
Red Mulberry *Morus rubra L.* Height, 60 to 70 ft. Diameter, 3 to 4 ft.	Massachusetts and Vermont to Florida, Nebraska, South Dakota, and Texas.	Light, soft, not strong, tough, coarse-grained, very durable in contact with the soil. Used in fencing, cooperage, ship- and boat-building. Fruit used in fattening hogs and poultry.	On low hills in rich soil. A rapid, hardy, profitable grower, with dense, shady foliage, and a very desirable ornamental tree. Sow seed as soon as ripe. Seed ripens in summer.

TABULAR CLASSIFICATION, ETC., OF THE IMPORTANT AMERICAN TIMBER TREES—(*Continued*).

Magnolias, Tulip-tree, Sweet Gum, Sycamore, Cherry, Locusts.

Name and Size.	Distribution.	Quality and Uses of Wood.	Remarks.
Magnolia (Big Laurel) *Magnolia fœtida (L.) Sarg.* Height, 60 to 80 ft. Diameter, 4 ft.	North Carolina to Florida, Arkansas and Texas.	Light, close-grained, moderately hard, easily worked. Used in cabinet-work, interior finish, and for fuel.	Flourishes in rich, moist soils, denuded river bottoms. A fairly rapid grower, with a beautiful foliage; a beautiful tree for parks, gardens, lawns, and streets in its range. Stratify seed and sow in spring. Seed ripens in autumn.
Cucumber Tree (Mountain Magnolia) *Magnolia acuminata L.* Height, 60 to 90 ft. Diameter, 3 ft.+	New York to Illinois, Alabama and Arkansas.	Light, soft, satiny, not strong, close-grained, durable. Used for water-pipes and troughs, lumber, flooring, and in cabinet-making.	Requires rich soil and humid climate. A rare tree, sought for lawn- and garden-planting because of its beautiful flowers and foliage. Stratify seed over winter and sow in spring. Seed ripens in autumn.
Tulip Tree *Liriodendron tulipifera, L.* Height, 100 to 160 ft. Diameter, 8 to 10 ft.	Vermont and Rhode Island to Florida, Mississippi, Michigan, Arkansas.	Light, soft, brittle, not strong. Used for interior finish, in boat-building for shingles, pumps, woodenware, and in construction.	In rich, moist soil along streams and on mountain slopes. A hardy and rapid grower, easily raised from seed, and a most beautiful tree. Sow seed in autumn as soon as ripe or stratify and sow in spring.

Sweet Gum *Liquidambar styraciflua L.* Height, 80 to 140 ft. Diameter, 4 ft.+	Connecticut to Florida, Missouri and Texas.	Heavy, hard, straight, close-grained, not strong, satiny; difficult to season, warps badly in drying. Used for outside finish of houses, street pavements, cheap dishes, fruit-boxes, and in cabinet-making. Leaves contain tannin.	Does well in poor soil, prefers moist or wet situations in river bottoms and swamps. Reproduction is good everywhere. A rapid grower and a desirable ornament for parks and roadsides. Sow seed in autumn in moist soil.
Sycamore (Plane tree) *Platanus occidentalis, L.* Height, 140 ft.+ Diameter, 10 ft.+	Maine to Florida, Nebraska and Texas.	Heavy, hard, close-grained. Used in making tobacco-boxes, ox-yokes, butchers' blocks, and for furniture and interior finish.	Borders of streams and rich bottom lands. Occasionally planted as an ornamental tree, but is often subject to fungal diseases, which stunt its growth.
Black Cherry *Prunus serotina Ehrh.* Height, 100 ft. Diameter, 4 ft.+	North Dakota to Nova Scotia, Florida and Texas.	Light, strong, hard, close-grained, satiny; takes a beautiful polish. Valuable for cabinet-making and interior finish, for tripods, surveyors' rods and cases, and spirit-levels.	A hardy, thrifty tree, and a rapid grower. Not fastidious as to soil. A very valuable tree. Desirable for timber-planting. Stratify seed and sow in spring. Fruit ripens in autumn.
Honey Locust *Gleditsia triacanthos L.* Height, ft. Diameter, 3 ft.	Minnesota to Pennsylvania and New York, Georgia, Nebraska, and Texas.	Heavy, hard, strong, and very durable in contact with the soil. Used for fence posts and rails, hubs of wheels, and in construction.	In fertile soil, borders of streams, and interval lands. Valuable for ornamental and timber planting, windbreaks, and hedges. Keep seed dry and scald just before planting. Seed ripens in autumn.

TABULAR CLASSIFICATION, ETC., OF THE IMPORTANT AMERICAN TIMBER TREES—(*Continued*).

Coffee Tree, Locust, Holly.

Name and Size.	Distribution.	Quality and Uses of Wood.	Remarks.
Coffee-tree *Gymnocladus dioicus (L.) Koch.* Height, 110 ft. Diameter, 2 to 3 ft.	Minnesota to New York, Nebraska, Indian Territory, and Tennessee.	Heavy, not very hard, strong, coarse-grained; liable to check in drying; durable in the soil. Used in cabinet-making and construction, and for fence posts and rails.	In bottom lands in rich or poor soil. A hardy and rapid grower, little liable to attacks of diseases. Often planted in parks and gardens. Keep seed dry and scald just before planting. Seeds mature in autumn.
Locust (Yellow Locust) *Robinia pseudacacia L.* Height, 70 to 80 ft. Diameter, 3 to 4 ft.	Pennsylvania to Georgia, Minnesota, Arkansas, and Indian Territory.	Heavy, very hard, strong, close-grained, very durable in contact with the soil. Used in ship-building, for posts, tree-nails, fuel, and lumber. Bark of root is tonic.	Thrives in deep, rich soil. Planted generally for timber and ornament. Sometimes spreads by underground roots, especially in less favorable situations. Has given rise to several varieties under cultivation. Keep seeds dry and scald just before planting. Seed matures in autumn.
American Holly. *Ilex opaca, Ait.* Height, 40 to 50 ft. Diameter, 2 to 3 ft.	Massachusetts to Florida, Indiana, Missouri, and Texas.	Light, tough, not strong, very close-grained, easily worked; takes a beautiful polish. Valued for cabinet-making, interior finish, and turnery.	Thrives in different soils. Common along creeks and river banks. Not very extensively cultivated. Difficult to transplant because of its thick, fleshy roots. Stratify seeds and sow in spring. Seed matures in autumn.

Maples (*Acer*).

Stratify seeds, of those that ripen in autumn, in sand for winter and sow in spring. Seeds of the kinds that ripen in early summer should be sown at once.

Silver Maple (White Maple) *Acer saccharinum L.* Height, 100 ft.+ Diameter, 2 ft.+	New Brunswick west to Southern Ontario, Eastern Dakota, Nebraska, Kansas, and Indian Territory.	Wood hard, strong, close-grained, but brittle, easily worked, not durable when exposed to the weather. Used in the manufacture of furniture, for interior finishing and flooring, ship-building and cabinet-making.	Requires loose, well-drained, loamy, calcareous soil, but will also grow in clay soil or stony ground if moderately moist. Growth rapid and persistent. Not well adapted to dry regions; liable to sun-scald in exposed locations. Suitable for street-planting if trunk is protected. Needs pruning often. Seed ripens in summer. Tolerant.
Sugar Maple (Hard Maple) (Rock Maple) *Acer saccharum, Marsh.* Height, 100 to 120 ft. Diameter, 2 ft.+	Common throughout Eastern North America, Newfoundland to Florida, west to Minnesota, Nebraska, Kansas, Eastern Texas.	Heavy, hard, strong, close-grained, tough, durable; takes a good polish. Color light brown, tinged with red. Used in manufacture of furniture, saddle-trees, shoe-lasts, shoe-pegs; in cabinet-making, for interior finishing, flooring, ship-building, school apparatus, gymnasium apparatus, musical instruments, calipers, rules, etc. Sap manufactured into maple-sugar.	Requires loose, loamy, calcareous, well-drained soil, but will grow on clay soil and stony ground with favorable moisture conditions. Growth moderately rapid and persistent. Does not do well in dry regions. Tolerant. Seed ripens in autumn.

TABULAR CLASSIFICATION, ETC., OF THE IMPORTANT AMERICAN TIMBER TREES—(*Continued*).

Maples and Buckeyes.

Name and Size.	Distribution.	Quality and Uses of Wood.	Remarks.
Red Maple (Swamp Maple) *Acer rubrum, Linn.* Height, 120 ft. Diameter, 2 to 4 ft.	Common throughout Eastern North America, New Brunswick to Southern Florida, west to Lake of the Woods, Eastern Dakota and Nebraska, Indian Territory to the valley of the Trinity River in Texas.	Heavy, close-grained, not very strong. Color light brown tinged with red. Used in manufacture of furniture, woodenware, and gun-stocks, and in turnery and cabinet-making.	Best in low, wet situations, but does well in moderately dry soil. Hardy and of slow growth. Seldom planted, but is a very ornamental tree. Seed ripens in early summer.
Oregon Maple *Acer macrophyllum, Pursh.* Height, 90 ft.+ Diameter, 2 ft.+	Coast of Alaska, 55° north, islands and coasts of British Columbia; widely distributed through Washington and Oregon, west of the Cascade Mountains to Southern California, along coast ranges, and western slope of the Sierra Nevadas.	Light, soft, not very strong, close-grained, easily worked, and takes a beautiful polish. Used for interior finishing, furniture, axe- and broom-handles, snow-shoes, frames, and in cabinet-making. Valuable for its "curled" wood.	One of the most valuable broad-leaved trees of Western North America. Growth rapid in moist climates. Requires low, rich ground. Seed ripens in autumn.
Box-elder (Ash-leaved Maple) *Acer negundo L.* Height, 60 to 70 ft. Diameter, 2 to 4 ft.	A widely distributed tree east of the Rocky Mountains, south to Western Texas and Northeastern Mexico, north to Winnipeg.	Light, soft, close-grained, not strong. Color creamy white; sapwood hardly distinguishable. Used in manufacture of cheap furniture, woodenware, paper pulp, and for interior finish, cooperage, and fuel.	A hardy, graceful tree of rapid growth. Best on low, rich ground. Because of its rapid growth and cheerful green foliage it has become a common chade tree of our prairie homes. Very hardy. Seed ripens in autumn.

Ohio Buckeye (Fetid Buckeye) *Æsculus glabra, Willd.* Height, 70 ft. Diameter, 2 ft.	Pennsylvania to Alabama, Iowa and Indian Territory.	Light, soft, not strong, close-grained, often blemished by dark lines of decay. Used for artificial limbs, woodenware, wooden hats, paper pulp, and lumber.	Bottom lands or banks of streams in rich, moist soil. A hardy tree, sometimes cultivated; makes a good park tree. Seeds treated as for other nut seeds.
Yellow Buckeye (Sweet Buckeye) *Æsculus octandra, Marsh.* Height, 90 ft. Diameter, 2 ft.+	Pennsylvania to Alabama, Iowa and Texas.	Light, soft, close-grained, difficult to split. Used for same purposes as Ohio Buckeye.	River bottoms and moist mountain slopes. A handsome and beautiful tree, hardy and able to withstand fungal diseases. Needs good soil when planted. Treat as for other nut seeds.

The Lindens (Basswood) (*Tilia*).

Large, handsome, valuable trees, with large leaves and a globular nut-like fruit. Seed matures the first season.

Basswood (American Linden) *Tilia americana L.* Height, 60 to 130 ft. Diameter, 2 to 4 ft.	New Brunswick to Georgia, Alabama, Texas, Assiniboia.	Light, soft, tough, close-grained, easily worked. Used in manufacture of cheap furniture, boxes, shelves, tool handles, carriage boxes, churns, and for lumber. The bast or inner bark is made into matting cordage.	Along banks of streams. A hardy tree, resisting drought well; desirable for street- or lawn-planting in favorable locations, and also for timber-planting. Newly transplanted trees liable to sun-scald unless protected. Seed starts second year after sowing.

TABULAR CLASSIFICATION, ETC., OF THE IMPORTANT AMERICAN TIMBER TREES—(*Continued*).

Basswood, Black Gum, Cotton Gum and Persimmon.

Name and Size.	Distribution.	Quality and Uses of Wood.	Remarks.
White Basswood *Tilia heterophylla, Vent.* Height, 50 to 60 ft. Diameter, 3 to 4 ft.	Pennsylvania to Florida, Illinois and Alabama.	Light, soft, close-grained. Used for same purposes as *Tilia americana.*	Banks of streams and wooded slopes in humid soil. One of the most beautiful trees of the American forest, but has not been extensively cultivated.
Black Gum (Tupelo) *Nyssa sylvatica, Marsh.* Height, 50 to 60 ft.+ Diameter, 3 ft.+	Maine to Florida, Michigan and Texas.	Heavy, soft, strong, very tough, hard to split, difficult to work; not durable in contact with the soil; liable to check unless carefully seasoned. Used for hubs of wheels, rollers in glass factories, ox-yokes, wharf-piles, soles of shoes.	In cultivation, flourishes in wet, undrained soil and on well-drained uplands. Found in swamps and wet places. It often has a large swelling at the base when growing in standing water. Easily raised from seed, but difficult to transplant.
Cotton Gum (Tupelo Gum) *Nyssa aquatica L.* Height, 80 to 100 ft. Diameter, 3 ft.+	Virginia to Florida, Illinois and Texas.	Light, soft, not strong, close-grained, difficult to split. Used in manufacture of woodenware, broom-handles, wooden shoes, fruit and vegetable boxes.	An inhabitant of swamps. Has large, usually swollen, hollow butts. Rarely found outside of its native swamps. Seed germinates second year.

Persimmon *Diospyros virginiana L.* Height, 30 to 50 ft. Diameter, 1 ft.+	Connecticut to Florida, Iowa and Texas.	Heavy, hard, strong, very close-grained. Used for shoe-lasts, plane-stocks, small domestic articles, shuttles, and in turnery. Fruit used commercially.	Adapted to a variety of soils. Valuable for its hardiness, good habits, handsome fruit, and its immunity from disease and attacks of insects. Easily raised from seed. Stratify seed over winter and sow in spring.

The Ash Tree (*Fraxinus*).

Keep seeds dry and cool over winter or stratify with sand and sow in spring. Autumn planting is a good practice in loose soil. Seed matures the first season.

Blue Ash *Fraxinus quadrangulata Michx.* Height, 120 ft. Diameter, 2 to 3 ft.	Minnesota to Michigan, Arkansas and Alabama.	Heavy, hard, close-grained, rather brittle. Used largely for flooring and in carriage-building. A blue dye is made from the inner bark.	On rich limestone hills to fertile bottom lands of river valleys. A hardy tree and a rapid grower; free from diseases and attacks of insects. Desirable for parks and lawns.
Black Ash *Fraxinus nigra, Marsh.* Height, 80 to 90 ft. Diameter, 1 to 2 ft.	Manitoba to Newfoundland, Arkansas, and Virginia.	Heavy, rather soft, not strong, tough, coarse-grained; durable in contact with the soil. Used in manufacture of baskets, in cabinet-making, for fences, barrel-hoops, and interior finish of houses.	Inhabits deep, cold swamps and low banks of streams and lakes. Short-lived when transplanted from its native swamps and not very satisfactory under cultivation.

TABULAR CLASSIFICATION, ETC., OF THE IMPORTANT AMERICAN TIMBER TREES—(*Continued*).

The Ash Tree (*Fraxinus*).

Name and Size.	Distribution.	Quality and Uses of Wood.	Remarks.
White Ash *Fraxinus americana L.* Height, 120 ft. Diameter, 2 to 6 ft.	Minnesota to Newfoundland, Texas and Florida.	Heavy, hard, tough, coarse-grained, brittle when old. Used in manufacture of agricultural implements, furniture, and for interior finish, baseball-bats, tennis-rackets, tool handles, churns, pails, tubs, etc.	Along streams in rich, moist soil. A very valuable timber tree, and a good ornamental tree. Inner bark of value for medicinal purposes. Young seedlings stand considerable shade.
Red Ash *Fraxinus pennsylvanica Marsh.* Height, 40 to 80 ft. Diameter, $1\frac{1}{2}$ ft.+	North Dakota to New Brunswick, Kansas, Alabama, and Florida.	Heavy, hard, rather strong, brittle, coarse-grained. Often used as substitute for White Ash, but wood is less valuable.	In low, rich, moist soil, along banks of lakes and streams. As a shade tree and ornamental tree it is less valuable than the White Ash.
Green Ash *Fraxinus lanceolata Borkh.* Height, 60 ft. Diameter, 2 ft.	Vermont to Saskatchewan River, Florida, Texas, and Arizona.	Heavy, hard, strong, brittle, rather coarse-grained. Often used as substitute for White Ash, but wood is of inferior quality.	On river banks. A hardy and persistent tree, with beautiful dark foliage and able to flourish in regions of small and uncertain rainfalls. A favorite ornamental tree in many Western States. Seedling plants grow rapidly and are easily transplanted.

Oregon Ash *Fraxinus oregona Nutt.* Height, 70 to 80 ft. Diameter, 4 ft.	Washington to California.	Light, hard, brittle, coarse-grained. Used in manufacture of furniture, for frames of carriages and wagons, in cooperage, interior finish of houses, and for fuel.	In rich, moist soil in neighborhood of streams. One of the most valuable hardwood trees of the Pacific forests. Often planted as a shade tree in streets.

The Catalpa (*Catalpa*).

Keep seed dry and cold in winter, and a good way is to leave them in the pods until used. Sow in spring. Seed matures the first season.

Common Catalpa (Catalpa) (Indian Bean) *Catalpa catalpa L.* Height, 60 ft. Diameter, 3 to 4 ft.	Georgia, Florida, Alabama, and Mississippi; has become widely naturalized throughout the Middle and Southern Atlantic States.	Soft, not strong, coarse-grained, durable in contact with the soil. Valued for fence-posts, rails, and other purposes where a durable wood is needed. Bark used for medicinal purposes.	Its large leaves and showy flowers make it a valuable ornamental tree. Has long been cultivated and is quite hardy.
Hardy Catalpa (Western Catalpa) *Catalpa speciosa, Warder.* Height, 120 ft. Diameter, 4 ft.+	Indiana to Tennessee, Missouri and Texas.	Light, soft, not strong, coarse-grained; very durable in contact with the soil. Used for furniture, interior finish, railway ties, fence posts and rails.	Its hardiness, durability, and rapid growth have made it valuable for prairie-planting, and also as an ornamental tree for parks and gardens. Much to be preferred to the former for planting.

GLOSSARY.

Accretion. Growth or formation by external additions to the tree.

Acorn. The fruit of an oak.

Albumen. Food stored up in seed with embryo; endosperm.

Alternate leaves. A single leaf at a node; not opposite (e.g. Willow).

Altimeter. An instrument for taking grades, levels, and heights.

Angle mirror. }
Angle prism. } Instruments for turning of angles in subdividing land.

Annual. Yearly; a plant which reaches maturity and dies at the end of a single season (e.g. Pea, Wheat).

Annual ring. The layer of wood formed each year.

Anther. The pollen-containing sac; enlarged part of stamen.

Arboriculture. The growing of trees for any purpose whatsoever.

Arboreous. Tree-like.

Assimilation. In plants, the production of organic matter from inorganic matter.

Axil. The angle formed by the junction of the leaf-blade, bract, petiole, pedicle or peduncle, with the branch or stalk from which it springs.

Back-firing. The burning, under control, of material in front of a fire to prevent its spreading.

Bark. A general term applied to all the tissues outside of the wood proper.

Basal. Attached to the base.

Basal area. The cross-sectional area of a tree near the ground, usually taken about four and one-half feet above ground to avoid the excessive swelling of the root buttresses.

Bast. The woody fibrous tissue of the inner bark.

Baummesser. An instrument for measuring the height of the trees, height and diameter at any part on the stem of a standing tree.

Berry. Botanically a fleshy fruit (e.g. Grape, Currant). Commonly applied to many kinds of fruits (e.g. Strawberry, Mulberry).

Blade of a leaf. The expanded portion; the wings.

Blight. The dying without apparent cause of the tenderer parts of plants.

Board-foot. The unit of board measure; equivalent to a board 12 in. $\times$ 12 in. $\times$ 1 in. One cubic foot is considered as equivalent to ten board feet, allowing for waste in working.

B. M. Abbreviation for board measure (q.v.).

Board measure (B. M.). The system used by lumbermen in which the board-foot (q.v.) is the unit.

Bract. A much-reduced leaf.

Broad-leaved trees. Applies to trees whose leaves have a broad flat surface, unlike the needle- or awl-shaped leaves of the conifers.

Budding. The operation and process of inserting a bud with the intention that it shall grow.

Bud-division. A term including all methods of propagation except by seed (e.g. Grafting, Layering, etc.).

Bud-variety. A strange variety or form appearing without obvious cause upon a plant or in cuttings or layers; a sport. A bud-variety springs from a bud in distinction from a seed-variety, which springs from a seed.

Callus. The new and protruding tissue which forms over a wound, as over the end of a cutting.

Calyx. Outer circle of leaves about a flower.

Cambium. In trees and shrubs, the layer of new growing tissue between the bark and wood.

Cants. A term used in mills to designate the pieces cut from the sides of a log and which are to be again cut into quarter-sawed lumber. It is sometimes also applied to the squared centerpiece of the log.

Carbon dioxide. A gas composed of one part of carbon to two parts of oxygen; carbonic-acid gas.

Carpel. A simple pistil or one of the divisions of a compound pistil.

Catkin. A scaly spike-like dense flower cluster (e.g. Willow, Birch).

Cell. The anatomical unit of living tissues.

Chlorophyll. The green coloring matter of plants; leaf-green.

Ciliate. Hairy on the margin.

Cleft leaf. Cut into lobes somewhat more than half the dedth of wings (e.g. Silver Maple).

Compass. A magnetic needle used to determine directions in the woods.

Compound leaf. One in which the blade or wings are composed of more than one part (e.g. Ohio Buckeye, Mountain Ash).

Cone. The flower or fruit of a conifer.

Conifer. A member of the Pine Family or Coniferæ.

Coniferous. Cone-bearing.

Cooperage. The business of making wooden vessels, as casks, barrels, tubs.

Coppice. A wood grown from sprouts.

Corolla. Inner leaves of the flower; generally distinguished from the calyx by being of a color other than green.

Cotyledon. One of the leaves of the embryo; a seed leaf.

Cross staff-head. An instrument for turning off angles in surveying land, consisting of an octagonal brass box with slits in the faces for sighting through.

Crowded. Said of trees when so closely grown that the development of their lateral branches is interfered with.

Crown of tree. See tree-crown.

Cuttage. The practice or process of multiplying plants by means of cuttings.

Cutting. A piece of a leaf, branch, stem, or root which when inserted in moist material is capable of sending out roots and forming a new plant; a slip.

Cycle. One of the circles of a flower.

Deciduous. Falling off; said of leaves that fall in autumn.

Dehiscent. Said of fruits that open at regular lines.

Delinquent tax lands. Lands on which taxes have not been paid. They are offered for sale at stated times after public notice, and tracts which find no buyers revert to the State.

Dentate. Toothed with teeth pointing outward, not forward.

Dibber. A pointed instrument used for making holes.

Dicotyledonous. Having two cotyledons or seed leaves.

Dioecious. Staminate and pistillate flowers borne on different plants.

Distillation product. The substance obtained by the decomposition of a compound.

Divided. Said of leaves when the wings are cut into divisions down to base or midrib.

Division. See Bud-division.

Drupe. A fruit with hard pit (endocarp) and soft exterior (exocarp) (e.g. Plum, Cherry, Peach).

Dry-rot. A kind of decay in wood.

Dust blanket. A layer of loose earth on the surface of the ground.

Embryo. The miniature plant in the seed.

Erosion. Wearing away.

Evergreen. Holding leaves over winter or longer until new leaves appear.

Family. In botanical classification, a group of plants thrown together because of some natural common resemblances. Sometimes used synonymously with order.

Firebreak. An opening, ploughed strip of land, or anything which prevents the spread of fires in forests or elsewhere.

Firefalls. Applied to areas where the trees have fallen owing to their roots having been burned off.

Flower. A part of the plant especially modified for the reproduction of the plant by seed.

Forest. A dense growth of trees.

Forest floor. The decayed leaves and twigs which cover the soil in forests.

Forestry. The growing of trees in groups.

Frost-hardy. Said of trees the new growth of which is not easily killed by frost.

Frost-tender. Said of trees the new growth of which is easily killed by frost.

Fruit. The seed-containing area derived from a single flower.

Fungi. Plural of fungus.

Fungous. Pertaining to fungi.

Fungus. A flowerless plant devoid of chlorophyll and drawing its nourishment from living organisms or decayed organic matter.

Genera. Plural of genus.

Generic name. The name of the genus to which the plant belongs and which with the name of the species forms the scientific name of the plant.

Genus. In botanical classification a group of plants having several or many natural common resemblances; a division of a family.

Germination. The act or process by which a seed or spore gives rise to a new and independent plant.

Glabrous. Smooth, not pubescent.

Glauber salts. Sodium sulphate.

Glaucous. Covered with a fine white powder, as that on a cabbage-leaf.

Graftage. A system of propagation comprising all methods by which plants are grown on roots of other plants

Grafting. The operation of inserting a scion in a plant.

Grafting-wax. A protective substance used in covering the junction of a graft with the stock or for the covering of wounds. Bailey's formula for a reliable wax: Resin four parts (by weight); beeswax two parts; tallow one part. Melt together and pour into a pail of cold water; then grease the hands and pull the wax until it is nearly white.

Hardy. Able to stand a given climate.

Heeling-in. The operation and process of temporarily covering the roots of plants to preserve them until wanted for permanent planting.

Height classes. The arrangement of trees into classes according to height.

Herb. A plant not woody.

Herbaceous. Not woody; said of plants that die to the ground each year.

Horticulture. The art and science of raising fruits, kitchen garden vegetables, flowers, and ornamental trees and shrubs.

Humus. Decomposed organic matter in the soil.

Hybrid. Plant derived from a cross between plants of different species.

Hybridizing. The operation or practice of crossing between species.

Hypsometer. An instrument for taking heights of trees.

Inarching. The operation and process of uniting contiguous plants or branches while the parts are both attached to their own roots.

Indehiscent. Not opening at regular lines; not dehiscent.

Indigenous. Native; i.e., growing naturally in a given region.

Inferior. Said of ovary when all the floral parts are attached above it (e.g. Iowa Crab).

Inflorescence. A flower cluster; mode of arrangement of flowers.

Insecticide. A substance employed to destroy insects.

Involucre. A bract or series of bracts subtending a flower-cluster or fruit-cluster.

Irregular. Said of flowers when the separate parts of each cycle are not of the same size and shape (e.g. Locust).

Jacob's-staff. A pointed staff which may be pushed into the ground and on which instruments are mounted for taking observations.

Joinery. The art of framing the finishing work making permanent wooden fittings and covering rough lumber.

Kerf. The cut made by the saw or the width of such cut.

Lanceolate. Said of leaves when from four to six times as long as broad, the broadest part below the middle and tapering upward or both upward and downward (e. g. Black Willow).

Larva (pl. *larvæ*). The worm-like stage of insects.

Layer. A shoot which, while attached to the plant, takes root at one or more places and forms a new plant.

Leaf-mould. Decayed leaves and other organic matter constituting the forest floor.

Leaflet. One of the wing divisions of a compound leaf.

Leather board. A material made from wood pulp and which resembles leather in color and texture.

Legume. A simple pod opening by both ventral and dorsal sutures; fruit of Pea family (e.g. Locust).

Leguminous. Pertaining to the family *Leguminosæ;* said of plants bearing legumes.

Loam. Friable, mellow, rich soil containing much humus.

Lobe. A projection or division of a leaf not more than half the depth of the wing.

Lyrate. A pinnatifid leaf of an obovate or spatulate outline with the end lobe large and roundish and the lower lobes small (e.g. Bur Oak).

Manure. Plant-food, any substance which promotes plant-growth.

Mono. Prefix meaning one.

Monœcious. Both staminate and pistillate flowers borne on the same plant (e.g. Black Walnut).

Mound-layering. Layering by making a mound about a plant (Fig. 27).

Mulch. Any loose material that protects the soil from frost or evaporation.

Muskeg. A term commonly applied to sphagnum swamps by the Indians and woodsmen of Northern Minnesota.

Narrow-leaved trees. Trees with needle- or awl-shaped leaves which expose no great surface to the light.

Nursery. A plot of ground set apart for the raising of plants that are to be transplanted elsewhere. An establishment for the raising of plants.

Oblong. About twice as long as broad with nearly parallel sides.

Obovate. The reverse of ovate.

Obtuse. Blunt, not acute (e.g. leaflets of Locust).

Odd-pinnate. Applied to pinnately compound leaves having a terminal leaflet (e.g. Ash).

Open-grown. Said of trees when not grown sufficiently close to other trees to be influenced by them.

Osiers. A class of willows used for baskets.

Ovary. The lower or enlarged part of the pistil bearing the ovules.

Ovate. About twice as long as broad and tapering from near the base to the apex (e.g. leaves of Balm of Gilead).

Ovoid. Egg-shaped.

Ovule. A rudimentary seed.

Palmate. Said of parts originating from a common point, as the veins, lobes, or divisions of a leaf (e.g. leaflets of Ohio Buckeye).

Panicle. A loose flower cluster (e.g. White Ash).

Papilionaceous. Butterfly-shaped: applied to flowers of the Pea family (e.g. Locust).

Paraboloid. The figure of revolution formed by turning a parabola about its axis.

Parasite. A plant or animal that lives upon and obtains its food from other living plants or animals.

Parietal placenta. A placenta upon the wall of the ovary (e.g Coffee-tree).

Parted. Separated nearly to the base.

Pedicel. A stalk of a single flower of a flower cluster.

Peduncle. A stalk of a solitary flower or the common stalk of a flower cluster.

Pendulous. Hanging.

Penta. Prefix, meaning five.

Perennial. A plant living more than two years.

Perfect flower. One having both essential organs, i.e. stamens and pistil (e.g. Iowa Crab).

Perianth. The floral envelopes.

Pericarp. The ripened ovary; the seed vessel.

Persistent. Remaining beyond the period when such parts generally fall.

Petal. One of the divisions of a corolla.

Petiole. Leaf-stalk.

Pinnate. Parts arranged on opposite sides of a main axis (e.g. leaflets of Mountain Ash).

Pistil. The part of the flower bearing the ovules and which ripens into the fruit.

Pistillate. Bearing pistils, but no fertile stamens. Often used synonymously with female.

Placenta. Place of attachment of ovules in an ovary.

Pollen. Small spores produced by the anthers for the fertilization of the ovules.

Pollination. The carrying of pollen from the anther to the stigma.

Polygamous. Perfect and unisexual flowers borne on the same plant.

Pome. Fruit represented by the Apple, Thorn, Quince, etc.

Propagation. The multiplication of plants.

Pruning. The removing of branches from a plant to improve its general appearance or to check or encourage growth.

Pubescent. Covered with fine, short hairs.

Quarter-sawing. The sawing on the radius, but as it is not practicable to do this exactly, the log is first quartered and then sawed into boards, cutting them alternately from each face of the quarter of the log. Sawed in this way the grain of the wood does not show nearly so conspicuously and varied as in that tangentially sawed, but the grain is narrower, and the wood sawed in this way does not warp nearly so much as that tangentially sawed, and is much more expensive.

Raceme. A simple inflorescence in which the flowers are on pedicels, and the lower open first (e g. Black Cherry).

Ranging-poles. Straight poles about eight feet long used by surveyors to indicate the direction of a line which is being measured or the position of points to be located.

Regular. Parts of each cycle of the perianth alike (e.g. Bird Cherry).

Root. A part of the plant which absorbs nourishment for the plant, or serves as a support. It may be underground or aerial.

Root-cutting. See Cutting.

Rudimentary. Imperfectly developed or in an early state of development.

Samara. A winged fruit (e.g. Maple).

Saprophyte. A plant which lives upon and obtains its food from dead organic matter.

Sapwood. The outer or latest formed wood of a woody plant.

Sawing. The two methods used in sawing are termed tangential sawing and quarter-sawing, q.v.

Scion. The part inserted in the stock in the various processes of graftage.

Seed. The body containing the embryo plant: the ripened ovule.

Seedling. In nursery practice a young plant grown from seed and not having been transplanted.

Seeding tree. A tree sufficiently mature to produce fruit.

Seed variety. A variety that comes true from seed.

Sepal. One of the divisions of the calyx.

Serrate. Saw-toothed (e.g. leaves of Balm of Gilead).

Sessile. Without stalk.

Sheath. In pines, the case-like part surrounding the base of the needle cluster.

Shrub. A woody plant with no main stem or trunk; a bush.

Silver grain. Bands or plates of medullary rays exposed radially on longitudinal section.

Simple. Composed of one part, not compound.

Sinuate. Strongly wavy.

Sinus. An indentation.

Solar-pit. A pit for rooting cuttings by the sun's heat (page 105).

Spatulate. Shaped like a spatula: broadly rounded at the apex, tapering toward the base.

Species. A division of a genus the plants of which seem to be derived from an immediate common ancestor.

Species class. A group of trees of the same species made in forest survey.

Specific gravity. Weight compared with distilled water at 4 degrees Centigrade. Where used here with reference to wood it refers to absolutely dry wood unless otherwise noted.

Spike. A simple, dense, raceme-like inflorescence with flowers sessile or nearly so.

Spore. A reproductive body, commonly applied to those borne by plants that do not produce seed. Analogous but not homologous to a seed.

Stamen. Pollen-bearing organ of a flower.

Staminate. Said of flowers bearing stamens, but no pistils. Often used synonymously with male.

Stem. The main axis or one of the main axes of a plant. It may be underground or aerial. Commonly used in place of petiole, pedicel, and peduncle.

Sterile. Not fertile, not able to reproduce.

Stigma. The part of the pistil upon which the pollen falls and germinates.

Stipule. A leaf appendage at the base of the blade or petiole, not always present (e.g. Black Willow).

Stock plants. Plants used to propagate from.

Stoma (pl. *stomata*) Breathing pores of leaves.

Stratification. A method of storing seeds with alternate layers of some other material, as sand or leaves.

Strobilus or Strobile. A cone (e.g. Pine, Lycopodium).

Stumpage. The standing timber.

Style. The stalk, if present, that joins the stigma to the ovary.

Sucker. A shoot from an underground root or stem; often applied to an adventitious shoot above ground.

Sun-scald. An injury to trees by sun (page 145).

Superior. Applied to ovary when attached on a level or above the other parts of the flower (e.g. Ohio Buckeye).

Surveyor-general. The officer whose duty it is to measure or to direct the measurement of logs and lumber.

Sylviculture. A synonym of the term forestry; the growing of trees in groups.

Tangential sawing. The common way of cutting logs by which the boards on each side of the centre board are sawed by a cut that is tangent to the annual rings. This method serves to bring out the grain of wood most conspicuously.

Tap-root. A central root running deep into the soil.

Tensile strength. The force which resists breaking or drawing asunder.

Tent-caterpillars. Caterpillars that build silky-like tents on trees and other plants.

Thorn. A hardened, sharp-pointed branch.

Tomentose. Clothed with matted woolly hair.

Top-worked. Said of trees that are grafted or budded at some distance above the ground.

Transit. A surveyor's instrument for measuring angles, etc.

Transpiration. The process by which water is taken up by the roots of plants and given off to the air through the leaves and branches.

Tree. A perennial woody plant with a single stem which from natural tendencies generally divides into two or more branches at some distance from the ground.

Tree-crown. That part of a tree that is branched, forming a head.

Tree-digger. Ordinarily a plough-like implement having a sharp knife-like blade that is drawn through the soil by a team and cuts the roots off the trees at a distance from the base of the tree-trunk. Where large quantities of trees are to be dug this is a most important implement. There are

various kinds: one style cuts on both sides of the row at one time.

Tri. Prefix, meaning three.

Triangulation. The method of survey by dividing into triangles.

Tripod. A three-legged support for an instrument.

Turgid. Distended; applied to leaves and other parts when filled with water.

Umbel. An umbrella-like form of inflorescence (e.g. flower clusters of Caraway, Parsnip).

Unisexual. Bearing either male or female organs, not both (e.g. flowers of Willows).

Variety. A distinct and valuable variation from the original.

Valve. One of the parts of a dehiscent pod.

Valvate. Opening by valves.

Volume. Amount or mass of a tree or log.

Water capital. The entire water of the earth.

Weed. A plant out of place, a generally troublesome plant, not of any appreciable economic value.

Whorl. Applied to leaves when arranged in a circle around the stem.

Wings of a leaf. The expanded portion; the blade. (Fig. 15.)

Windbreak. A single row or belt of trees, which serves as a protection from wind.

Wood. The hardened tissue of a stem; a forest.

Working-plan. A prearrangement of the method of growing and harvesting a forest crop of a particular tract.

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Practical Forestry, by John Gifford. Pub. by D. Appleton & Co.

Scribner's Lumber and Log Book, by S. E. Fisher, Rochester, New York.

Forestry in Minnesota, by Samuel B. Green. Geo. and Nat. Hist. Survey of Minnesota.

Forest and Water, by Abbot Kinney, Post Publishing Co.

Report of the Pennsylvania Department of Agriculture, Division of Forestry, 1895.

Reports of the Forest Commission of Maine, 1896.

Reports of the Chief Forest Fire Warden, Minnesota.

Report of the Clerk of Forestry for Ontario.

Report of the Fisheries, Game, and Forest Commission of the State of New York.

Sylva of North America, 12 vols. Prof. C. S. Sargent. Pub. by Houghton, Mifflin & Co.

Economics of Forestry, by Dr. B. E. Fernow. Pub. by Thomas Y. Crowell & Co.

FOREIGN BOOKS.

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Schlich's Manual of Forestry, 4 vols. Pub. by Bradbury, Agnew & Co.

Forestry in British India, by B. Ribbentrop. Pub. by Government of India, Calcutta.

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The Woodlot, Bulletin No. 42.
The Decay of Timber, Bureau of Plant Industry, Bulletin No. 14.
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